1.1 Rayleigh Scattering

Rayleigh scattering refers to elastic scattering of light by the medium. A perfect homogeneous medium with a uniform dielectric constant does not scatter light except in the forward direction (refraction). The scattering arises due to dielectric inhomogeneities in the medium. These could be due to thermodynamic fluctuations (Fabelinskii 1968) in density, entropy and composition (in the case of a multicomponent medium) as well as due to defects. Isobaric density fluctuations and those in entropy and composition (nonpropagating diffusive fluctuations) contribute to Rayleigh scattering whereas adiabatic density fluctuations give rise to Brillouin scattering. The time dependence of the fluctuations cause broadening of the Rayleigh peak. In most of the dielectric crystals, the observed Rayleigh scattering (Daybell et al. 1968) is much more than expected due to thermodynamic fluctuations alone (Landau and Placzek 1934, Wehner and Klein 1972), indicating that the most of the observed scattering comes from defects. Defects in a single crystal not only include point defects like vacancies, interstitials and impurities but also their complexes and extended defects like dislocations, precipitates of a second phase etc. In addition there could be scattering from domain boundaries (where they exist).
The scattering due to defects arises basically due to a change in dielectric constant caused by their presence. The change in dielectric constant could be local as well as in the region surrounding the defect. The change at the defect site arises because electronic polarisability of the atoms constituting the defect is different from that of the host atoms. Theory of light scattering from small dielectric spheres (size much smaller than the wavelength of light) is well known (see for example Kerker 1969). Theimer and Plint (1958) have estimated the light scattering from point defects considering the change in electronic polarisability. In addition to the change at the defect site, the dielectric constant can change in the neighbourhood of the defect also, due to the strain field $\bar{\varepsilon} (\vec{r})$ surrounding the defect (elasto-optic effect) given by the relation

$$\Delta \bar{\varepsilon}'(\vec{r}) = \bar{p} \cdot \bar{\varepsilon}(\vec{r})$$

(1.1)

where $\Delta \bar{\varepsilon}'(\vec{r})$ is the change in dielectric constant at $\vec{r}$ and $\bar{p}$ is the elasto-optic fourth rank tensor (Nye 1960). The strain field arises due to atomic rearrangement around the defect, e.g., around an impurity in an alkali halide crystal it arises due to ionic size mismatch. The strain field and hence the change in dielectric constant is in general long ranged (it goes like $r^{-3}$ in the case of a point defect and $r^{-2}$ in the case of a line defect) and has the potential of substantially increasing the scattering
cross-section of the defect. Lyubchanskii et al. (1976) and recently Mills (1980) have pointed out that the strain field can significantly alter the scattering due to a point defect. Thus most of the Rayleigh scattering from dielectric crystals, which comes from defects, is expected to have contributions from the change in dielectric constant at the defect site (core contribution) as well as in its neighbourhood (strain field contribution). In the next section we describe the general theory of light scattering from defects which can take both the contributions into account. Green's function method is used to obtain the scattered electromagnetic field in the framework of classical electromagnetic theory.

1.2 Theory of Light Scattering from Defects

Consider a defect located at the origin \( \vec{r} = 0 \) in an otherwise homogeneous isotropic dielectric medium of dielectric constant \( \varepsilon_o \). Let \( \Delta \vec{\varepsilon}(\vec{r}) \) be the change in dielectric constant of the medium due to the introduction of the defect. The dielectric tensor of the perturbed medium is then

\[
\vec{\varepsilon}(\vec{r}) = \varepsilon_o \vec{1} + \Delta \vec{\varepsilon}(\vec{r})
\]

where \( \vec{1} \) is a 3 x 3 unit matrix. Let us denote the electric and magnetic fields of the incident electromagnetic wave of frequency \( \omega \) by \( \vec{E}_o \) and \( \vec{H}_o \) respectively and those of
scattered electromagnetic wave by \( \vec{E}' \) and \( \vec{H}' \). The total electric and magnetic fields, at any point \( \vec{r} \) in space, given as

\[
\begin{align*}
\vec{E} &= \vec{E}_0 + \vec{E}' \\
\vec{H} &= \vec{H}_0 + \vec{H}'
\end{align*}
\]

(1.3)

satisfy the Maxwell's equations

\[
\begin{align*}
\vec{\nabla} \cdot \vec{D} &= 0 \\
\vec{\nabla} \times \vec{E} &= -\frac{1}{c} \frac{\partial \vec{H}}{\partial t} \\
\vec{\nabla} \times \vec{H} &= \frac{1}{c} \frac{\partial \vec{D}}{\partial t} \\
\vec{\nabla} \cdot \vec{B} &= 0
\end{align*}
\]

(1.4)

where

\[
\vec{D} = \vec{\varepsilon} \cdot \vec{E}
\]

(1.5)

and \( \vec{B} = \vec{\mu} \cdot \vec{H} \) are the displacement vector and the magnetic induction respectively. \( \vec{\mu} \) is the magnetic permeability of the medium. For a nonmagnetic medium \( \vec{\mu} = \vec{1} \). Substituting for \( \vec{\varepsilon} \) and \( \vec{E} \) in equation (1.5) and retaining terms only up to first order one gets the scattered displacement vector \( \vec{D}' \) as

\[
\vec{D}' = \varepsilon_0 \vec{E}' + \Delta \vec{\varepsilon} \cdot \vec{E}_0
\]

(1.6)

The incident as well as total electromagnetic fields satisfy the Maxwell's equations, consequently the scattered fields also satisfy Maxwell's equations. Taking the curl of
equation (1.4b) and substituting value of curl $\overline{H}'$ from equation (1.4c) we get
\[ \overline{\nabla} \times \overline{\nabla} \times \overline{E}' = k^2 \overline{D}' / \varepsilon_0 \] (1.7)
where the time dependence of the scattered displacement vector $\overline{D}'$ is taken as $\exp(-i\omega t)$ and $k = \sqrt{\varepsilon_0} \omega / c$ is the magnitude of incident wave vector. Substituting for $\overline{E}'$ in equation (1.7) from equation (1.6) we get
\[ (\nabla^2 + k^2) \overline{D}' = -\overline{\nabla} \times \overline{\nabla} \times (\Delta \overline{E} \cdot \overline{E}_o) \] (1.8)
where $\overline{\nabla} \cdot \overline{D}' = 0$ has been used. Equation (1.8) is an inhomogeneous Helmholtz equation for the scattered displacement vector $\overline{D}'$ and the right hand side of it represents the source term. If $G(\overline{r}, \overline{r}')$ is the Green's function for the Helmholtz equation satisfying
\[ (\nabla^2 + k^2) G(\overline{r}, \overline{r}') = \delta (\overline{r} - \overline{r}') \] (1.9)
then the scattered displacement vector $\overline{D}'$ can simply be written as (Landau and Lifshitz 1960)
\[ \overline{D}'(\overline{r}) = -\int d^3 \overline{r}' G(\overline{r}, \overline{r}') \overline{\nabla}' \times \overline{\nabla}' \times [\Delta \overline{E}(\overline{r}') \cdot \overline{E}_o(\overline{r}')] \] (1.10)
where $\overline{\nabla}'$ is the del operator with respect to $\overline{r}'$. At the point of observation $\overline{r}$, which is far from the defect, $\overline{D}' = \varepsilon_0 \overline{E}'$ is true and the scattered electric
field $E'(r)$ is then given as

$$E'(r) = -\frac{1}{\varepsilon_0} \int d^3 \mathbf{r} \mathbf{G}(\mathbf{r}, \mathbf{r}') \nabla' \times \nabla' [\Delta \mathbf{E}(\mathbf{r}') \cdot E_o(\mathbf{r}')]$$

(1.11)

The scattered field thus obtained can be used to deduce the scattering cross-section.

1.2.1 Point defects

The scattered field $E'(r)$ from a point defect propagates radially outward in all $4\pi$ directions, hence the differential scattering cross-section $\sigma(\Omega)$ is the ratio of the power scattered per unit solid angle in direction $\Omega$ to the incident intensity of the field, and is given as (see e.g. Mills 1980)

$$\sigma(\Omega) = r^2 |E'(r)|^2 / |E_o(r)|^2$$

(1.12)

The total scattering cross-section is obtained by integrating over all solid angles.

1.2.2 Line defect

Consider scattering by an infinite line defect lying along z-axis in a homogeneous dielectric medium. Let the incident electromagnetic wave be incident perpendicular to z-axis. There exists a cylindrical symmetry about the line defect (z-axis), consequently scattered field is also
z-independent and propagates radially outward perpendicular to z-axis. The power scattered per radian in direction θ by unit length of the defect is proportional to \( \rho |\mathbf{E}'(\rho)|^2 \) where cylindrical coordinates \((\rho, \theta, z) = (x, y, z)\) have been used. The quantity

\[
\sigma(\theta) = \rho |\mathbf{E}'(\rho)|^2 / |\mathbf{E}_0(\rho)|^2
\]

(1.13)

represents the scattering efficiency of the line scatterer and is more appropriately called as differential scattering width (Eyges 1972) rather than cross-section as it has dimensions of length rather than that of area.

The theory of light scattering presented in this section can be used to estimate the contributions of various mechanisms to light scattering from basic defects like point defects, dislocations etc. once \( \Delta \varepsilon \) is known. The evaluation of the latter quantity is discussed presently.

1.3 Various Contributions to Light Scattering from Defects

As already remarked, Rayleigh scattering from defects is determined by the change in the dielectric constant due to the presence of defects, this change having two contributions, a core contribution (due to the polarisability of the defect) and a strain field contribution (elasto-optic
effect). The total change in dielectric constant at any point \( \mathbf{r} \) due to the introduction of a point defect at \( \mathbf{r} = 0 \) can be written as

\[
\Delta \tilde{\varepsilon}(\mathbf{r}) = \begin{cases} 
\Delta \varepsilon_0 \mathbf{1} & |\mathbf{r}| \leq r_0 \\
\Delta \varepsilon'(\mathbf{r}) & |\mathbf{r}| > r_0
\end{cases}
\]  
(1.14)

where \( \Delta \varepsilon_0 \) represents the core contribution. The core is treated as a sphere of radius \( r_0 \), outside which strain field \( \tilde{\varepsilon}(\mathbf{r}) \) can be described within the framework of linear elasticity. The above discussion is equally valid for a line defect provided \( \mathbf{r} \) is appropriately replaced by \( \mathbf{P} \) and core is treated as a cylinder of radius \( P_0 \).

Recently Mills (1980) has estimated the contribution of lattice strain (arising due to ionic size mismatch) around an isovalent impurity in ionic crystals to the light scattering cross-section. It has been pointed out that lattice strains can significantly contribute to light scattering in certain ionic crystals. Additional strain, hereafter called as Coulomb strain, can be caused by the Coulomb interaction between a defect having a net effective charge (vacancy and aliovalent impurity) and its neighbours. It is important to know the contributions of various mechanisms to light scattering from point defects and their complexes. As far as line defects are concerned, the contribution from the strain field of a dislocation to light scattering has so far been
treated only qualitatively (Moriya and Ogawa 1980, Lyubchanskii et al. 1976). The dependence of the scattered intensity from alkali halide crystals on the orientation of the crystallographic axes relative to the incident and scattering directions suggests (Sibley 1963, Plint and Sibley 1965) the existence of cylindrical scattering objects in the crystal. Most of the experimental results have been interpreted using the well-known theory of light scattering from dielectric cylinders (see for example Kerker 1969). Estimated diameters range from 100 Å to 500 Å and lengths from $3 \times 10^4$ Å to $5 \times 10^5$ Å in a number of doped and nominally pure alkali halide crystals (Plint and Sibley 1965 and references therein). The origin of dielectric cylinders of such dimensions has been qualitatively sought in the charge clouds formed by impurities and vacancies around charged dislocations in alkali halide crystals. Although the formation of such charge clouds around dislocations, commonly known as decoration, is well known in ionic crystals (Eshelby et al. 1958, Whitworth 1975), the interpretation of light scattering results in terms of scattering from decorated dislocations is controversial (Whitworth 1975). There has been no attempt to estimate quantitatively the contributions of the strain field and that of decoration to the light scattering from dislocations.
1.4 Defect Kinetics and Related Phenomena in Doped Crystals

In view of the light scattering experiments to be discussed later, we present next a brief general discussion of defect kinetics and related phenomena, as relevant to the present work.

Point defects in a crystal can migrate from one point to another by making a number of thermally activated random jumps whereas dislocations are mobile only when stresses are applied. The energy barrier for jump from one site to another is called the migration energy of the defect, and it determines the mobility of the defect (Barr and Lidiard 1970). In ionic crystals defects which have net effective charge (anion and cation vacancies and aliovalent impurities) give rise to ionic conduction when an external electric field is applied. When the doping level is higher than the solubility of the corresponding impurity at a given temperature, impurities form precipitates as they migrate through the matrix.

1.4.1 Impurity states in doped alkali halide crystals

Among the insulating crystals, alkali halides are the ones studied in greatest detail both theoretically and experimentally due to their simple structure and ionic
nature. In alkali halides, Schottky defects are energetically more favourable (Corish et al. 1977) than the Frenkel defects. Temperature dependence of ionic conductivity allows one to distinguish between four distinct temperature regions where different types of defects exist dominantly. Figure 1.1 schematically shows logarithm of $\sigma_e T$ as a function of inverse temperature for an alkali halide crystal AX doped with divalent cation impurity B where $\sigma_e$ is the ionic conductivity and T is the absolute temperature. It is observed that the cation vacancy migration energy is smaller than that for an anion vacancy (Corish et al. 1977) and hence the ionic conductivity is determined by the concentration of cation vacancies. Region marked I in Fig.1.1 is the intrinsic region where the number of thermally produced Schottky vacancy pairs is much higher than the number of divalent cation impurities and the ionic conductivity is determined by the thermally-produced cation vacancy concentration. As the temperature is reduced, the effect of impurities becomes more and more significant and one enters region II - the extrinsic region, where impurities dominate over thermally produced intrinsic defects and the concentration of cation vacancies is same as that of divalent cation impurities. Region III is that of association where divalent cation impurities and cation vacancies form impurity-vacancy dipoles and the number of free cation vacancies, which determines the ionic conductivity, reduces as temperature is lowered. Binding
Fig. 1.1 Log of $\sigma_e T$ verses inverse temperature for a NaCl single crystal doped with 282 ppm of Lead (in melt) (Baltog et al. 1974).
ergy of impurity-vacancy dipole determines the free cation vacancy concentration (Corish and Jacobs 1973). When the temperature is lowered further, the concentration of impurities becomes higher than the solubility limit and one encounters region IV - the precipitation region. Excess impurities form precipitates as thermodynamic equilibrium is reached. In general, stable precipitates are of BX\textsubscript{2} phase while a metastable Suzuki phase (Suzuki 1961), which is a per lattice formed by an ordered arrangement of impurity-vacancy dipoles with formulae 6AX\textsubscript{2}BX\textsubscript{2} has also been frequently observed (Kirk et al. 1975). The criterion for the formation of Suzuki phase has been obtained by Sors and Lilley (1975a) \( r_{++}/r_{+} < 1.2 \) where \( r_{++} \) and \( r_{+} \) are the radii of B\textsuperscript{2+} and respectively. In heavily doped crystals (doping level \( \sim 1\% \)) other phases like 2AX\textsubscript{2}BX\textsubscript{2} may also be present, e.g., NaCl: Cd\textsuperscript{2+} (Spengler and Kaiser 1974) and in KCl: Ba\textsuperscript{2+} (Andreev and Klimov 1980).

2 Impurity solubility - Enthalpy of solution

In alkali halides the solubility of divalent cation impurities is very low (\( \sim \) ppm) near room temperature and strongly temperature dependent (Brown and Hoodless 1957). The solution of impurity ions B\textsuperscript{2+} into host matrix can be represented by the reaction (Lidiard 1957)
\[ BX_2(\text{crystal}) \rightarrow [B^{2+} + V_c + 2Cl^-] - G \]  
\text{(in host AX)} \quad (1.15)

where \( V_c \) is a cation vacancy which is to be created to maintain charge neutrality and

\[ G = \gamma - \eta T \]  
\text{(1.16)}

is the free energy of solution. \( \gamma \) and \( \eta \) are respectively the enthalpy and entropy of solution. Equation (1.15) may be taken as a reversible reaction and law of mass action may be applied to obtain free impurity solubility \( C_f \) (Lidiard 1957) as

\[ C_f(T) = \exp(-G/2k_BT) \]  
\text{(1.17)}

where \( k_B \) is the Boltzmann constant. Figueroa and Laredo (1972) have considered associated impurity solubility also and the total impurity solubility \( C_t \) is then given as

\[ C_t(T) = \exp(-G/2k_BT) + Z_1 \exp[-(G-G_a)/k_BT] \]  
\text{(1.18)}

where the second term on right hand side represents associated impurity solubility. \( Z_1 \) is the number of orientations an associated impurity (impurity-vacancy dipole) can take and \( G_a \) is the free energy of association (Figueroa and Laredo 1972). However, associated impurity solubility is small compared to free impurity solubility and is significant only at high temperatures.
Conventionally, enthalpy of solution $\chi$ of divalent cation impurities in alkali halides is determined by ionic conductivity measurements (Brown and Hoodless 1967, Figueroa and Laredo 1972). One determines the temperature corresponding to the knee between region III (association) and region IV (precipitation) of ionic conductivity. This temperature is usually taken as the dissolution temperature $T_d$ at which impurities have just dissolved into host matrix. Doping level dependence of the dissolution temperature is then used (Brown and Hoodless 1967) to determine enthalpy of solution.

1.4.3 Study of precipitation by light scattering and ultramicroscopy

Precipitates being dielectric inhomogeneities in an otherwise homogeneous dielectric medium scatter light strongly. The dependence of scattering on shape and size of a precipitate makes light scattering a useful technique in studying average shape and size of precipitates (Plint and Sibley 1965, Nottin 1970 and Marculescu et al. 1980). When the precipitate size is much smaller than the wavelength of light $\lambda$ (precipitate radius $a < \lambda/20$) its scattering cross section is given as (Kerker 1969)

$$\sigma = \frac{8\pi^3}{3} \left(\frac{\Delta \varepsilon}{\lambda^4}\right)^2 v^2$$

(1.19)
where $\Delta \epsilon$ is the change in dielectric constant in the precipitate from that of the host crystal and $v$ is volume of the precipitate. For precipitates of sizes larger than $\lambda/20$ the scattering law departs from that of $\lambda^{-4}$ and corrections to the cross-section become significant. For precipitates of the size of the order of $\lambda$, Mie theory must be used to get the scattering cross-section (Kerker 1969).

If there are $N$ precipitates per unit volume, and $\langle v \rangle$ is the average volume of a precipitate, then the scattered intensity $I_{sc}$ at a distance $r$ in direction $\Omega$ is given as

$$I_{sc}(r, \Omega) = I_0 \sigma(\Omega) V N/r^2$$  \hspace{1cm} (1.20)

where $I_0$ is the incident intensity and $V$ is the scattering volume. It may be noted that $\sigma(\Omega)$ is proportional to $\langle v \rangle^2$. It is common to define Rayleigh ratio $R(\Omega) = I_{sc}(r, \Omega) r^2/I_0 V$ which represents the scattering efficiency of the crystal. Rayleigh ratio defined in this way has dimension of $\text{cm}^{-1}$ and is given as

$$R(\Omega) = N \sigma(\Omega)$$  \hspace{1cm} (1.21)

The Rayleigh ratio integrated over all $4\pi$ solid angles is called turbidity. Inverse of turbidity is called extinction length and represents the distance over which the intensity of a propagating beam falls to its $1/e$ value.
It can be seen from equation (1.19) and (1.20) that in the process of growth (dissolution) of precipitates the scattered intensity increases (decreases) (Geguzin and Konon) 1973, Baltog et al. 1974). Thus the kinetics of precipitation (dissolution) can be studied by observing the time evolution of the scattered intensity (Blistanov et al. 1972). The process of formation and dissolution of precipitates has been studied by light scattering in a number of doped alkali halide crystals, e.g., in LiF:Mg\(^{2+}\) (Blistanov et al. 1972), in KCl:Pb\(^{2+}\) (Bekturganov et al. 1974, Marculescu et al. 1976) etc.

Besides scattering, optical microscopy of the interior of the crystal is another way of studying the precipitates. This technique gives information about their spatial distribution and morphology. Ultramicroscopy examines the scattered light from the interior of a transparent dielectric crystal in a direction perpendicular to that of propagation of the incident beam (Amelinckx 1956). Use of finely focussed laser beams has made ultramicroscopy a much more sensitive and attractive technique (Moriya and Ogawa 1978, 1980) than optical microscopy in transmission geometry (Sors and Lilley 1975b, Andreev et al. 1980) in the study of the interior of transparent dielectric crystals. In alkali halides also ultramicroscopy has been used quite successfully to study the spatial distribution of precipitates (Amelinckx 1956, Nottin 1970).
Dependence of light scattering from doped alkali halide crystals on the orientation of the crystallographic axes relative to incident and scattering direction has indicated presence of plate and rod like scattering centres aligned along crystallographic directions along with spherical scatterers (Nottin 1970, Baltog et al. 1972). Ultramicroscopy has revealed precipitates which are rod like as well as spherical ones aligned along crystallographic directions (Hauret and Girard-Nottin 1966, Andreev et al. 1980). Precipitates formed at the nodes of hexagonal dislocation network have also been seen (Amelinckx 1956). Thus ultramicroscopy and conventional light scattering form a useful complementary pair of techniques. As will be described later, in our work we have resorted to both.

1.4.4 Study of precipitation by other techniques

Precipitation in doped alkali halide crystals has been studied by a number of other techniques (for a review see Hartmanova 1971). Precipitation process causes small changes in density (Andreev and Klimov 1972) and hence density measurements have been extensively used in the study of precipitation (Andreev et al. 1978 and references therein). A number of other techniques like dielectric loss (Dryden and Harvey 1969, Strutt and Lilley 1981), ionic thermoconductivity (Capelletti 1968, Collins and Crawford Jr. 1971), optical absorption (Bonnel 1973,
Lopez et al. (1980), Luminescence (Collins and Crawford Jr. 1971) and NMR (Berg et al. 1977) have been used for studying aggregation and precipitation of free and associated impurities in alkali halide crystals with various divalent cation impurities. All these techniques give information about the concentration of unprecipitated impurities and hence by studying the time evolution of unprecipitated fraction one indirectly studies the aggregation and precipitation kinetics whereas light scattering and ultramicroscopic techniques directly probe the precipitates. As precipitation influences mechanical properties also, yield stress and microhardness measurements (Dryden et al. 1965, Garcia-Sole et al. 1980, Marculescu et al. 1980) have been used to study manifestations of precipitation process. Replica transmission electron microscopy (TEM) has also been used to study the morphology and distribution of precipitates (Kirk et al. 1975).

The studies using dielectric loss, ionic thermoconductivity, optical absorption luminescence and NMR techniques are mainly concentrated on identifying the order of the kinetics of impurity-vacancy dipoles (Unger and Perlman 1974, Cook and Dryden 1975) and resolving the controversy of second order kinetic verses third order kinetics (Lilley 1980). Yield stress measurements have indicated precipitation hardening. Replica TEM has shown existance of metastable Suzuki phase precipitates as well as those of stable BX2
phase (Distler et al. 1971, Guerrero et al. 1981). Densitometric studies have indicated two stages of precipitation (Andreev and Klimov 1978 and references therein) in a number of doped alkali halide crystals. The first stage (low temperature stage) being unaffected by prior mechanical strain while the second stage (high temperature stage) has been influenced by the strain. The two stages of precipitation have been qualitatively assigned to homogeneous and inhomogeneous precipitations.

A more direct method to study the distribution of precipitates as well as the precipitation stages is obviously, as pointed out in the previous section, of light scattering complimented by ultramicroscopy. The kinetics can also be investigated to obtain activation enthalpies of the processes, as will be shown later, using the same light scattering technique. This kind of analysis of light scattering data has not received much attention in the past.

1.5 An Overview of the Thesis

With the background just presented, we are now in a position to have a broad overview of the author's investigations, the details of which are discussed in the chapters to follow.
We have seen that the strain field surrounding the defect has potential of significantly contributing to the light scattering from defects. However, certain aspects of the strain field contributions to light scattering from some of the basic defects (point defects and dislocations) have either not been dealt with or been treated only qualitatively. It is important to understand the contributions from each of the sources for various types of defects. Such knowledge facilitates the use of light scattering as a probe for studying defect properties in dielectric solids.

Chapter 2 deals with light scattering from point defects and their complexes in ionic crystals with NaCl structure. The Coulomb displacement field is modelled in isotropic elastic continuum limit. The Coulomb strain field is considered together with lattice strain and change in electronic polarisability while calculating the scattering cross-section using Green's function method described in section 1.2. The recent reported observation that Fe$^{2+}$ impurity in KBr crystal scatters much more strongly than Rb$^+$ (in KBr) is explained on the basis of present model (Arora et al. 1982).

In Chapter 3 we make quantitative evaluation of light scattering from dislocations, with due regard to the contributions arising from the strain field as well as from
the core. The wavelength dependences of the two contributions to scattering width are obtained. The estimated turbidity associated with light scattering by dislocations in alkali halide crystals is compared with reported experimental numbers for pure crystals.

The theory developed in Chapters 2 and 3 is used to calculate light scattering from decorated dislocations in Chapter 4. The contribution of the strain field of dislocation as well as that of point defects to the change in dielectric constant is considered in addition to that of polarisability of the decorating point defects. Recent light scattering data and their interpretations are discussed in light of the results of present calculations.

Chapter 5 discusses the application of light scattering technique to the study of processes associated with defect kinetics in doped alkali halide crystal, namely, formation and dissolution of precipitates in NaCl single crystals doped with lead impurity. The experimental set up employed in this study is described. The results of isochronal and isothermal annealing after suitable thermal and thermo-mechanical treatments are reported. The two stages of precipitation have been investigated by combining ultra-microscopy with light scattering. The conclusions arrived at Chapter 4 have been used to explain present experimental
results. A technique to obtain enthalpy of solution from light scattering studies, not reported in literature so far, is described and has been applied to the system NaCl: Pb$^{2+}$.

In Chapter 6 results obtained in the present investigations are summarised. A few possible suggestions for the future are also indicated.
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