Chapter 2

REVIEW OF LITERATURE

The second chapter contains survey of literature which will include different works on dark clouds. photometric and polarimetric study in dark clouds, by different authors.

There have been many studies on dark clouds or star forming regions by many authors (Lynds 1971: Villere & Black 1980: Leung et al. 1982; Young et al. 1982; Leung 1985; Joshi et al. 1985; Lada 1987; Kane et al. 1994; Yun et al. 1997; Larson et al. 2000; Sen et al.2000: Ward-Thompson et al. 2000; Wiebe & Watson 2001; Khanzadyan et al. 2002; Launhardt & Sargent 2001; Matthews & Wilson 2000; Wolf-Chase et al. 2003; Draine 2003; Ghosh et al. 2005; Kandori et al. 2005; Massi et al. 2005; Gouliermis et al. 2006; Kirk et al. 2006; Maheswar & Bhatt 2006; Naoi et al. 2006; Whittet 2007). The cloud

CB3 in the present study is associated with different generations of star formations. as suggested by the presence of a NIR Young Stellar Object (YSO) (Yun and Clemens 1994). a 1.3 mm object (Launhardt and Henning 1997), and a sub-mm source (Huard et al. 2000). This cloud also contains IRAS point source. which lies among these objects. A molecular outflow was also detected by Yun and Clemens (1992) in CO. Massi et al. (2004) discovered H2 and [FeII] emission knots and protostellar jets in this cloud. The cloud CB25 is quiescent having no activity and the cloud CB39 has been found to contain YSO. IRAS point sources and CO out flows (Clemens & Barvainis 1988. Clemens et al.1991).

There also have been many studies on interstellar polarization. dark cloud polarization caused by dust grains to trace the strength and geometry of the magnetic field. which plays an important role in the dynamics of the star formation process (Hiltner 1956; Jones & Spitzer 1967; Purcell & Spitzer 1971; Verba et al. 1976; Wilking et al. 1980; McDavid 1984; Mc Cutcheon et al. 1986; Heyer et al. 1987; Verba et al. 1988; Whittet et al. 1994; Goodman & Whittet 1995; Lazarian 1995; Kane et al. 1995; Larson et al. 1996; Mathis 1996; Matthews & Wilson 2000; Matthews et al. 2001; Jones 2003; Wolf et al. 2003; Clayton et al. 2004).

The properties of the ambient magnetic field are not easy to determine. While magnetic fields are generally thought to give support against gravitational collapse (Shu et al. 1987). mediate disk formation and accretion (Mouschovias & Paleologou 1980; Königl 1989) and help direct outflows (Blandford & Payne 1982), the strengths of the magnetic fields are very difficult to measure in molecular clouds (Goodman et al. 1989). It is relatively easy to measure the directional pattern of the magnetic field. via polarimetry. in the near environs of dark clouds and cores (Verba et al. 1986). So many polarimetric studies of background starlight seen through dense clouds (visual extinction $A_V >> 1$) have been carried out at near-infrared wavelengths to determine the magnetic field structure in these dense regions (Wilking et al. 1979; Moneti et al. 1984; Hodapp 1984; 1990; Sato et al. 1988; Tamura et al. 1987, 1988; Goodman et al. 1992). There has been huge expansion in the field of thermal emission polarimetry i.e., measuring polarized thermal emission from dust at far-infrared through millimeter wavelengths. It informs us about the large (Schleuning 1998) and small scale magnetic field structure in star forming regions. Hough (2006) describes the importance of polarimetry in modern astronomy, providing insight into physical processes occurring in different systems.

Several works have been made in the past (Mathis et al. 1977; Draine & Lee 1984; Bailey & Williams 1988; Allamandola & Tielens 1989; Kim & Martin 1994; Lazarian & Draine 1999a; Whittet et al. 2001; Lazarian 2003; Draine 2003; Weingartner & Draine 2003; Cho & Lazarian 2005; Kirk et al. 2006; Vaidya et al. 2007) on interstellar dust grains, the size distribution and properties. Scattering from grains provides one of the diagnostics for their nature and composition. Scattering can be observed in three general situations: (a) scattering by diffuse dust of the general incident interstellar radiation field - which is strongly concentrated in the galactic plane (b) reflection nebulae with a known source of illumination and (c) scattering of the general interstellar radiation field by a dark cloud, seen at high enough latitudes so that it contrasts with a relatively dark sky background. Gustav Mie showed with detailed calculations that for light with very large λ (compared to the size of the scattering particle), the intensity of the scattered light are very small. For light with very small λ, however, the intensity reaches a constant value, independent of λ.

When radiation interacts with the particle, part of the radiation is absorbed and part of it is scattered. Thus the total amount of radiation lost from the incident beam (extinction) is the sum total of the absorbed and scattered components. These are generally expressed in terms of dimensionless efficiency factors (efficiency of the scattering process) Q_{sca} and Q_{abs} for the sctering and absorption components. The efficiency factors for the total extinction is given by $Q_{ext} = Q_{sca} + Q_{abs}$ so that the effective cross-section for scattering are $C_{sca} = a^2 . Q_{sca}$. $C_{abs} = a^2 . Q_{abs}$. $C_{ext} = a^2 . Q_{ext}$. say, for spherical grains of radius 'a'. These quantities depend upon the shape, structure and composition of the grains. Different scattering models had been developed (Whitney & Hartmann 1992, 1993; Fischer et al. 1994, 1996 and Lucas & Roche 1997, 1998) to interpret polarization maps. The most important achievement of these models is in developing maps that produce qualititavely good matches to observed polarization maps of reflection nebulae around YSOs. Polarization maps of galaxies have been used as probes of galactic dust distributions and also large-scale galactic magnetic fields (Scarrott et al. 1990; Wolstencroft et al. 1995; Draper et al. 1995; Scarrott 1996; Beck & Hoernes 1996). The polarization in the optical and infrared arises through dust scattering of starlight and by dichroic extinction. For dust scattering, the scattered light is polarized perpendicular to the scattering plane, which yields a centrosymmetric pattern of the polarization vectors when viewing a galaxy pole-on and polarization vectors perpendicular to the disk for galaxies viewed at high inclinations (Jura 1982; Matsumura & Seki 1989; Bianchi et al. 1996; Bianchi et al. 1996). Dichroic extinction is the selective attenuation of different components of the electric vector when light passes through a medium in which the grains are aligned by a magnetic field. When there is a magnetic field present, the grains align with their short axes parallel to the field (Roberge 1996). As light traverses these aligned grains. the component of the electric vector parallel to the long axis of the grains is preferentially absorbed. which gives a net polarization parallel to the magnetic field direction. This mechanism is responsible for the interstellar polarization observed toward many stars in our own Galaxy and has been used to map out the Galactic magnetic field (Mathewson & Ford 1970). Wood (1997) presented polarization map which demonstrates the need to include dichroism in any models attempting to reproduce galactic polarization *properties. Zagury (2002) reviewed the properties of the scattered starlight that* contaminates the spectrum of the reddened star. Davis & Greenstein (1951) worked on the polarization of starlight by aligned dust grains and computed polarization and extinction of light for a cloud of small particles having any specified distribution of orientations. Assuming that the grains contain mostly compounds of hydrogen with about 12% iron by weight. presumably also in compounds. containing a few percent iron they put forward a mechanism for orienting the rapidly spinning grains which is the small nonconservative torque due to paramagnetic relaxation in material. Later a pioneering work by Purcell (1979) showed a way to make grain alignment more efficient. Purcell noticed that grains at high rates are not so susceptible to the randomization induced by gaseous collisions and introduced several processes that are bound to make grains very fast rotators. He made a study on the suprathermal rotation of interstellar grains and discussed on different possible consequences of suprathermal motion. A grain can be rotated suprathermally that is with energy much greater than k times any temperature in the system. The torque that drives it can arise from gas atom bombardment. photoelectric emission and H_2 recombination (Purcell's mechanism of small grain alignment).

New physics in grains (Lazarian & Draine 1999a) explains inefficiency of alignment of small grains by Purcell's mechanism. Roberge & Lazarian (1999) found that paramagnetic alignment of thermally rotating grains is inefficient. Greaves et al. (1999) studied polarization in the submillimeter range in the star-forming regions Mon R2, DR21 and W3-IRS4 and put some constraints on dust grain alignment. They found that the degrees and directions of polarization observed in DR21 are found to be wavelength dependent at 800 to 1100 μm. From the search of previous JCMT polarimetry results they showed that for about half the sources observed, p(1100) is greater than p(800), while in most of the other sources the two values of p are in agreement. The explanation for this result is that there are two (or more) non-cospatial grain populations along the line of sight, with different degrees of polarizability and different opacity indices which can produce bias effects in the polarization percentage and position angle. It is discussed by Lazarian (2003) that very small grains are likely to be aligned by paramagnetic mechanism. Another mechanism of grain alignment known as Relative Torque(RT) mechanism, first introduced by Dolginov (1972), was more recently studied by Draine & Weingartner(1996,1997) and Weingartner & Draine(2003), where their efficiency was demonstrated using numerical solutions. RT have been demonstrated to be efficient in a laboratory set up (Abbas et al. 2004). While it was originally believed that RT can not align grains at optical depths larger than Av~ 2, a recent work (Cho & Lazarian 2005) demonstrated that the efficiency of RT increases sharply with the grain size and therefore bigger grains that exist within molecular clouds can be aligned for Av more than 10.

Recently many works have been done on grain model (Li & Greenberg 1998; Zubko et al. 2004; Iati et al.2004; Draine 2004; Voshchinnikov et al.2005; Voshchinnikov et al.2006; Stark et al.2006; Vaidya et al. 2007), to study dust grains, their properties and extinction caused by them. They found that the structure, shape and in homogeneity in the grains play an important role in producing extinction.

Many studies have been carried out on dust particles and extinction caused by them over the past several decades (Hulst 1949; Feen-Berg 1932; Stebbin & Whitford 1943,1948; Johnson & Morgan 1953; Hulst 1957; Seaton 1979; Savage & Mathis 1979; Holm et al 1982; Hecht et al. 1984; Stetson 1987; Cardelli & Savage 1988; Clayton & Mathis 1988; Cardelli et al. 1988; Cardelli & Clayton 1988; Mathis 1990; Fitzpatric & Massa 1990; Clayton et al. 1992; Cardelli et al 1992; Welty & Fowler 1992; Lada et al. 1994; Wood et al. 1994; Moreira & Yun 1995; Aleves & Yun 1995; Larson et al. 1996; Henden 1996; Arce & Goodman 1999; Choi et al. 1999; Gupta et al. 2005; Indebetouw et al. 2005; Nishiyama 2006).

Cardelli et al. (1989) made a study on the relationship between infrared, optical and ultraviolet extinction. Using the extinction data of Fitzpatric and Massa (1986, 1988) for the ultraviolet and various sources for the optical and near infrared, they derived an average extinction law over the wavelength range 3.5 $\mu m \geq \lambda \geq 0.125$ μm, which can be used to calculate colour excess or to deredden observations. O' Donnell (1994) worked on the Rv-dependent optical and near ultraviolet extinction and derived extinctions at the wavelengths, for 22 stars, with a range of values of Rv, from the sample of CCM89. Kim et al. (1994) worked on the size distribution of interstellar dust particles by fitting parameterized extinction curve (Cardelli et al 1989) for the diffuse interstellar medium(ISM) and a dense cloud region.

Schlegel et al. (1998) published an all sky reddening map by observing far-infrared emission from dust which is much more better than the previous existing all sky reddening map of Burstein & Heiles (1978, 1982). Larson et al. (2000) estimated the size distribution of dust grains in a particular line of sight from the extinction curve observed in the near-infrared through the ultraviolet. The grain-size distribution in this line of sight contains a relative excess of grains with radius a< 0.1 μm as well as a relative deficiency of grains with radius a> 0.1 μm as compared with the average diffuse interstellar medium and other clouds at high latitude. Whittet et al. (2001) studied the interstellar extinction and polarization in the Taurus dark clouds and the optical properties of dust near the diffuse and dense clod interface. They presented observations of interstellar linear polarization in the spectral range 0.35- 2.2 μm for several stars reddened by dust in the Taurus region. Naoi et al. (2006) made a study on near - infrared extinction law in the ρ ophiuchi and chamaeleon dark clouds and determined and compared the colour excess ratios for those clouds. Whittet (2007) studied an isolated dark globule and estimated extinction and distance.

However, from different studies on polarization and extinction, it has been revealed that although quite large values of polarization could be associated with large extinction (Hodapp 1987; Zaritsky et al. 1987; Jones 1989), the polarization efficiency appears to be low for dark clouds (Jones et al. 1984; Klebe & Jones 1990). Serkowski et al. (1975) found from their extensive study of interstellar polarization at visual wavelengths, that while greater extinction tended to go with greater polarization, a simple linear correlation did not exist. Further, in a plot of P_{max} vs E (B-V), the data were distributed over all values of polarization below an upper envelope given by the relation P_{max} = 9.0 E (B-V).

Jones (1989) made polarimetric study at near infrared wavelengths to investigate the behaviour of interstellar polarization as a function of optical depth in front of a source for extinctions exceeding 100 mag at V and found a good correlation between interstellar polarization and interstellar extinction at 2.2μm for almost all lines of sight which has a slope less than unity and is independent of the physical path length. The observed trend in polarization with extinction was interpreted with a model involving equal contributions from a uniform component and a random component to the interstellar magnetic field. In most studies of the p-A_V relation. it is found that there is a fuzzy upper bound to the amount of polarization possible for a particular extinction and that observed points lie anywhere below this upper limit in the p- A_V plane (Moneti et al. 1984; Whittet et al. 1994). Gerakines et al. (1995) used polarimetric observations of background field stars to investigate alignment in the Taurus Dark Cloud for extinctions in the magnitude range $0 < A_K < 2.5$ ($0 < A_V < 25$) and found a strong systematic trend in polarization efficiency with extinction. represented by a power law $p/A \propto A^{-0.56}$. The result was discussed with a number of possible interpretations. Using near-IR polarimetry. Goodman et al.(1992.1995) found that there was a trend of decreasing polarization efficiency with extinction in the cold dark clouds. Arce et al. (1998) studied the relation between polarization percentage (p) and extinction (Av) in the cold dark (Taurus dark cloud complex) clouds. They found two trends in their p-Av study: (1) stars that are background to the warm ISM show an increase in p with Av. and (2) the percentage of polarization of stars that are background to cold dark clouds does not increase with extinction. They offered a set of guidelines to where the polarization maps can be taken as faithful representations of the magnetic field projected onto the plane of the sky and where they cannot. Fosalba et al. (2002) made a statistical analysis of the largest compilation available of Galactic starlight polarization data and found a nearly linear growth of mean polarization degree with extinction. The amplitude of this correlation shows that interstellar grains are not fully aligned with the Galactic magnetic field, which can be interpreted as the effect of a large random component of the field. Jones (2003) studied polarimetry at 1.65μm of stars shining through the filamentary dark cloud GF 9. They found the dust grains within GF 9- core were aligned and producing polarization in extinction.

Dey (2001) proposed a theoretical model of the cloud CB 39 and determined the optical thickness of this star forming cloud as a measure of extinction. It is seen from her study that the cloud CB 39 is not spherically shaped rather irregular. More recently, Sen et al. (2005) modelled the cloud as a simple dichroic polarizing sphere which explains why polarization need not always increases with total extinction Av as one moves towards the centre of the cloud. Their analysis shows that the observed polarization depends largely on the geometry of the magnetic field within the cloud. The actual cause of the lack of polarizing power for dust in some cold dark clouds is still debated.

In the present study, an attempt has been made to find any possible relationship between polarization and extinction of background starlight of the clouds. After reduction, analysis and comparison of the observed data, the result obtained is reported with some discussions.