Abstract: GRAIN ALIGNMENT BY FERROMAGNETIC IMPURITIES

John S. Mathis, Washburn Obs., Univ. of Wisconsin-Madison

The observed wavelength dependence of linear polarization, and its variation from region to region (Wilking, Lebofsky, and Riecke, A. J., 87, 695, 1982), can be explained by the following assumptions: (1) Interstellar grains resemble interplanetary grains, in that they are composed of collections of small particles coagulated together into elongated masses. (2) A fraction of the small particles are ferromagnetic. Presumably these are either metallic Fe or magnetite, Fe_3O_4. (3) If and only if a large grain contains one or more magnetic particles is the grain aligned in the galactic magnetic field. (4) The magnetic particles stick only to silicate grains because of chemical similarities, or (equivalently) any pure-carbon grains in the diffuse ISM are too spherical to produce polarization. (5) Grains in dense regions, such as the outer parts of molecular clouds, are larger than those in the diffuse ISM because of coagulation of the grains rather than accretion of icy mantles. These regions are known to have larger than normal values of $\lambda(max)$, the wavelength of the maximum of linear polarization.

The above assumptions are sufficient to allow the calculation of the wavelength dependence of the polarization, assuming that aligned particles behave like spinning cylinders. There is a free parameter, which is the size of the grain which has a probability of 0.5 of containing one or more magnetic particles. With the standard MRN power-law size distribution I recover the average $p(\lambda,\lambda(max))$ relationship ("Serkowski's Law"), which is a function containing two parameters. For dense regions, the size distribution of the coagulated particles determines the form of $p(\lambda,\lambda(max))$. I have tried two different but possible forms of the size distribution; both of them can provide the observed polarization. The correct size distribution for the coagulated particles depends on such quantities as the probability of shattering large particles by small ones, as opposed to sticking the two together. However, it is clear that coagulation of grains can lead to a size distribution which gives both the correct wavelength dependence of polarization and its variation from region to region.