Infrared Polarimetry and the Magnetic Field in External Galaxies

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Jones (1989) finds that interstellar polarization at 2.2um is well correlated with the line of sight extinction to reddened stars in the Milky Way. This is true primarily for lines of sight that cross interstellar magnetic field lines. The correlation does not, however, have a slope of unity. Jones interpreted this result by modeling the net interstellar polarization as due to grains aligned by an interstellar magnetic field made up of equal contributions of a uniform component and a random component.

Recently, Jones and Klebe (1989) present infrared polarimetric measurements of six infrared luminous galaxies. Three of the galaxies (Arp 220, NGC 6240 and Mrk 273) show polarization consistent with purely interstellar polarization. Compared to the Milky Way, the strength of the polarization is low for the extinction inferred from the near infrared colors of the central portions of these galaxies. Jones and Klebe interpret these results to indicate that the projected magnetic field in front of the central bulges of these galaxies is more disordered than in the Milky Way, perhaps as a consequence of a recent merger, as suggested in images of these galaxies.

Here we report for the first time infrared polarimetry of the normal edge on spiral NGC 4565 and the interacting pair NGC 3690/IC 694 (Arp 299). These observations, as well as previous observations, were made with the Minnesota Infrared Polarimeter on the IRTF during the past year. Our goal is to explore the magnetic field geometry in these galaxies and to determine the extent to which the field is ordered and uniform.

Figure 1 shows the results of polarimetry for stars in the Milky Way taken from the literature plotted and as small dots. The dashed line is the model from Jones (1989). The three infrared luminous galaxies showing only interstellar polarization are plotted as open triangles. The polarization of the bulge of NGC 4565 seen through its dust lane is plotted as an open square. Note that for NGC 4565 the polarization per unit optical depth in the disk is as high as in the Milky Way. This indicates that the trend seen in the Milky Way is probably typical for normal undisturbed spiral galaxies.

The polarimetry of the two nuclei of Arp 299 (sources A and B) are plotted as open circles. Note that as with the infrared luminous galaxies, the polarization of Arp 299 is well below the relation for normal spiral galaxies. This suggests that the projected magnetic field in front of the nuclei of all of these galaxies contains a greater random component than is the case in normal spiral galaxies. In order to lower the polarization by a factor of two to three compared to the Milky Way a considerable disruption of the magnetic field along the line of sight is required. This suggests that the process of interaction between galaxies or the onset of a massive starburst significantly disrupts the magnetic field geometry. In NGC 6240 for example, all memory of the original net magnetic field direction has been lost.

Jones, T. J. and Klebe, D. I., 1989, Ap. J., 340, in press.

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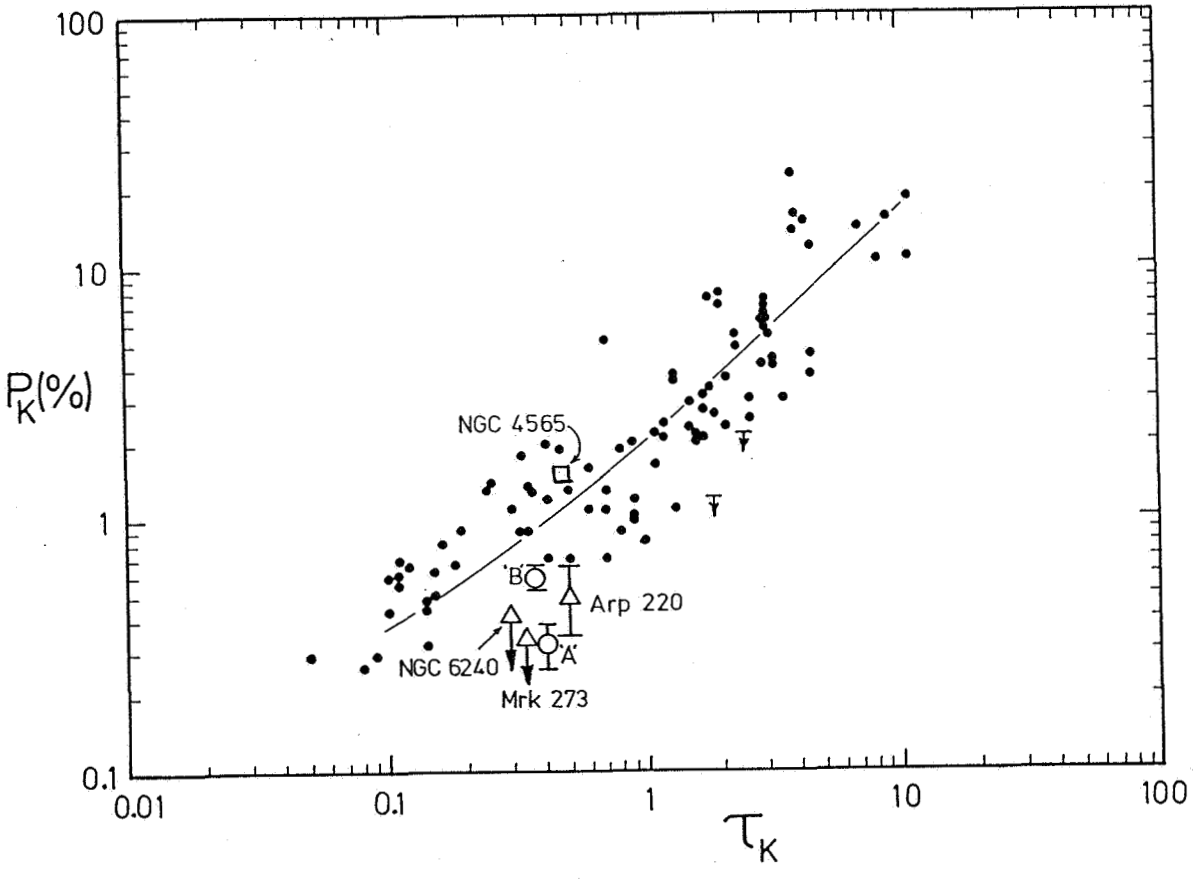

Figure 1. The relationship between interstellar polarization at 2.2um and extinction. The dots are individual stars in the Milky Way. The solid line is the model for the Milky Way from Jones (1989). The normal spiral galaxy NGC 4565 compares well with the Milky Way, but the infrared luminous galaxies and interacting galaxies are systematically weaker.