N93-26805

A COMPARISON OF EXTINCTION CURVES FOR DUST IN GALAXIES OF DIFFERENT HUBBLE TYPES

Leisa K. Townsley (University of Wyoming) and Jill S. Price (Bentley College)

A sample of 25 galaxies of various Hubble types has been observed in a variety of filters (Table 1). Extinction curves have been generated for absorption regions in these galaxies using a technique which previously had been used on just a few galaxies; for example, NGC 205 (Price and Grasdalen 1983), NGC 185 (Price 1985), NGC 3077 (Price and Gullixson 1989), and M31 (Walterbos 1986). The results from these studies suggested that there may be systematic trends in dust properties with Hubble type. This would not be surprising; dust properties should vary with metallicity, for example. It is well known that some galaxies (e.g. dwarfs) have lower metallicities than others (e.g. giant spirals or cD ellipticals) and their interstellar materials should reflect this difference.

In our own Galaxy, one can use the known properties of a certain spectral type to directly determine how much light is extinguished as a function of wavelength for a particular star. At the distances of most other galaxies, however, we cannot resolve individual stars so another method is needed. Therefore instead of looking at how much light is extinguished from an individual star, we look at how much galaxy light is extinguished, using the symmetry of the galaxy. This is accomplished in the following manner. The total amount of flux from a given point in a dust cloud (or an aperture) will be comprised of two parts: the flux from in front of the dust cloud, F, and the flux from behind the cloud, B, which has been extinguished by the dust, $B[\exp(-\tau)]$. The total amount of flux we see from that region of the galaxy, S, is the sum:

$$S = F + B[\exp(-\tau)] \qquad (1)$$

Suppose we could estimate how much flux, T, we should see from that portion of the galaxy if the dust were not present. If we assign a "luminosity distance" into the galaxy, x, so that the amount of flux F emanating from in front of the dust cloud is a fraction x of the amount of flux expected from that region of the galaxy, then:

$$F = xT \quad \text{and} \quad B = (1-x)T, \text{ since } T = F + B \qquad (2)$$

If we substitute the expressions in equation (2) into equation (1) and divide by T, we obtain:

$$F/T = x + (1-x)[\exp(-\tau)] \qquad (3)$$

This expression can be generated for data in different filters, and for n equations, we have n + 1 variables. This would appear to be a problem, except that we do get some help from galactic dust clouds, which have known ratios of optical depths. If we use one of these known ratios it reduces the number of unknowns to the same as the number of equations, allowing us to solve for x, and thus determine all the other optical depths. Alternatively, values of x may be assumed, and we can solve for the optical depths, generating extinction curves and comparing them to the average extinction curve for dust in our Galaxy. The ratio F/T is generated by observing how much flux is emanating from the dust cloud, F, and determining the expected flux, T, from that region of the galaxy. This may be accomplished by either scanning across the dust on a line of galaxy symmetry or by doing spot photometry on the dust and comparing to a spot diametrically across the galaxy on a line of symmetry. Assumed values of x are restricted by the values of F/T, because since:

$$\tau = -\ln[(F - x)/(1 - x)], \qquad (4)$$

certain values of x are not allowed.

In practice this method allows us a way to see if dust is similar to galactic dust or not. If, for example, there is no value of x which gives a match with galactic optical depth ratios, then the dust in the galaxy differs from galactic dust in some quantitative way which can be probed with models of light scattering by dust grains. Caution is required, of course, because there is a wide range in dust properties even for dust within our own Galaxy. Careful thought must also be accorded to the error bars on our data points. Nonetheless in the past it has been possible to show that, at least in NGC 185, the dust was not like galactic dust (Price 1985), while in NGC 3077, the dust looked like galactic dust (Price and Gullixson 1989).

Results of this study may provide some clues, after modeling, to the structure and composition of dust in galaxies of various Hubble types. This should be helpful to theorists who wish to find out how star formation processes vary with Hubble type.

References

Price, J.S. 1985, Ap. J., 297, 652.
Price, J.S., and Grasdalen, G.L. 1983, Ap. J., 275, 559.
Price, J.S., and Gullixson, C.A. 1989, Ap. J., 337, 658.
Walterbos, R. 1986, Ph.D. thesis, University of Leiden.

TABLE 1

X = Observations Obtained (Filter Wavelengths in nm)

Galaxy/Type	550	633	805	425	500	600	700	800	900	485	535
NGC 128/S0$_2$ (8)pec	X	X	X	X	X	X	X	X		X	X
NGC 520/IrrII	X	X	X	X	X	X	X	X		X	X
NGC 2685/S0$_3$ (7)pec	X	X	X	X	X	X	X	X	X	X	X
NGC 4150/S0pec	X	X	X	X	X	X	X	X	X	X	X
NGC 4691/SBbpec	X	X	X	X	X	X	X	X	X	X	X
NGC 4753/S0pec	X	X	X	X	X	X	X	X	X	X	X
NGC 4826/Sab(s)	X	X	X	X	X	X	X	X	X	X	X
NGC 5195/IrrII	X	X	X	X	X	X	X	X	X	X	X
NGC 5273/S0/a	X	X	X	X	X	X	X	X	X	X	X
NGC 5614/Sa(s)	X	X	X	X	X	X	X	X	X	X	X
NGC 7331/Sb(rs)	X	X	X	X	X	X					
NGC 23/Sb	X	X	X	X	X	X					
NGC 157/Sc(s)	X	X	X	X	X	X					
NGC 210/Sb(rs)	X	X	X	X	X	X					
NGC 253/Sc(s)	X	X	X	X	X	X					
NGC 309/Sc(r)	X	X	X	X	X	X					
NGC 891/Sb	X	X	X	X	X	X					
NGC 972/Sbpec	X	X	X	X	X	X					
NGC 1068/Sb(rs)	X	X	X	X	X	X					
NGC 1084/Sc(s)	X	X	X	X	X	X					
NGC 1232/Sc(rs)	X	X	X	X	X	X					
NGC 1637/SBc(s)	X	X	X	X	X	X	X	X	X		
NGC 1832/SBb(r)	X	X	X	X	X	X	X	X	X		
NGC 1964/Sb	X	X	X	X	X	X	X	X	X		
NGC 2855/Sa(r)	X	X	X	X	X	X	X	X	X	X	X