A New Southern Hemisphere Galactic Extinction Map Based on Surface Brightnesses of External Galaxies

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1 Introduction

The precise surface brightness values listed for about 12000 homogeneously selected galaxies in "The Surface Photometry Catalogue of the ESO-Uppsala Galaxies" (Lauberts and Valentijn 1989, hereafter ESO-LV; see also *Messenger* **34**, 10 and **56**, 31 and this issue) have been used to derive Galactic extinction values for a large part of the Southern Sky. The new extinction measures are thought to reflect the effect of the diffuse interstellar medium in our own Galaxy and the technique we have employed should trace the same component as has been studied before in so-called 'reddening' studies. The current analysis uses parameters of *detected* galaxies, in similarity with previous reddening studies, and is not sensitive to those regions of the sky that might be that heavily obscured that we start to miss objects located behind these regions. These heavily obscured regions can be better traced by galaxy counts, a separate project, which is still in progress. Here, we announce some first results of our extinction studies, that resulted in a 3 degree resolution extinction map of the Southern Sky with a $\sigma(A_B) \approx 0.13^m$ and $\sigma(E(B-V)) \approx 0.06^m$.

2 The Technique

The hitherto most frequently used model for the extinction in the Southern Galactic hemisphere (Burstein, Heiles) is exclusively based on the mapping of neutral hydrogen. Since this mapping was done with a rather poor spatial sampling, the resultant extinction map was grossly dominated by interpolations of data. Furthermore, using HI data relies on a constant HI to extinction ratio. The overall value of this ratio is uncertain by at least a factor two, and is thought to deviate more locally. This motivated Burstein and Heiles also to include galaxy counts, when deriving their extinction model for the Northern Hemisphere, which unfortunately could not be done for the South. Motivated by the recent availability of the photometric data in the ESO-LV catalogue we have started some statistical experiments to see whether the data would allow an improvement on this situation.

Although the surface brightness of an external galaxy at a particular single band should respond linear to the extinction in the Galaxy, such single band surface brightness values are not a good extinction indicator, since they have a too large scatter around the mean value ($\sigma \approx 0.6$ mag). If however, we have a sample of galaxies with measured surface brightness in *two* bands (B and R for ESO-LV), then we can take into account the fact that they are strongly correlated with each other (Fig.1) and use as a measure of extinction of each individual galaxy, its distance from the average regression curve of unreddened surface brightnesses, measured along the direction of the reddening vector (see Fig.2). However, in order to obtain this distance we have to know the location of the curve describing the unreddened surface brightnesses, but to obtain this curve we have to know extinction for every galaxy – just the set of values we are looking for. The only solution of this difficulty is to obtain *both* the extinctions and the location of the curve simultanously - in one step. This is possible with help of the "analysis of variance" statistical technique. This technique reproduced the well documented ratio A_R/A_B =0.565 and in the further processing this value has been adopted. In constructing the unreddened curve we made use of the parameter Q which is independent of extinction but dependent on surface brightness. In short, the statistical analysis solves the function $f(Q)$ and $A_B(l,b)$ in one step. The introduction of the Q parameter is closely related to a similar parameter used for the analysis of the reddening of stars.

The full description of the above method and its application to ESO-LV is expected to be published soon (Chołoniewski & Valentijn 1991, in preparation) The uncertainty of the derived extinction in the B band is $\sigma(A_B) \approx 0.4^m$ *per galaxy.* This corresponds to $\sigma(E(B-V)) \approx 0.1^m$ which is comparable to the accuracy of extinction estimates deduced from the photometry of stars. When averaging over larger areas (ESO-LV has about one galaxy per square degree) a formal much more accurate value for such an area can be obtained. For instance, the average A_B over one ESO sky survey plate has been deduced with an error of 0.1^m, which corresponds to an uncertainty in $E(B-R) \approx 0.04$. Such values are useful to evaluate the large scale distribution of the extinction, but indeed, we do not know how much spatial structure is present within these averaged areas, a problem inherent in this sort of research.

3 The map

In figure 3. we present a map of the relative extinction in the Southern Hemisphere. The photometry of external galaxies can not provide absolute extinction, or in other words, it can not provide the zero point. Formally, the technique provides the relative extinction compared to an overall mean of $A_B = 0$. We have not finalized the constant yet (our work on this is still in progress) but we can easily deduce a lower limit for it. We can not allow negative extinctions to occur (the white and blue regions in fig 3.) and more formally, we can deconvolve the observed frequency distribution of A_B with the formal σA_B error function. This way, we derive a lower limit to the zero point of 0.4^m, which has been included in the scale of figure 3.

Our understanding of fig. 3 is that most of the structures that can be seen are real. We checked that they do not correlate with the spatial distribution of the target galaxies, while around the Southern Galactic pole we could observe a good spatial correspondence with the IRAS cirrus maps of Boulanger *et al.* We can also compare the extinction in a small, but still significantly large, part of the Northern Galactic Hemisphere (92 ESO survey plates) with that in the Southern Galactic Hemiphere. In the regions of absolute galactic latitute in the range $10° - 30°$, we find on average about 0.1^m more extinction (A_B) in the South. When our evaluation of the lower limit on the zero-point is correct, then the average extinction at low galactic latitutes ($< 70°$) should be $A_B > 0.25^m$.

4 Availability of the data

Our results for the relative extinction in the B band (A_B) in our Galaxy will be avaliable in the following forms:

1. In our paper we anticipate a printed list of overall extinction values for each of the 404 ESO sky survey plates that were assessed in the ESO-LV project.
2. A computer program AEJ (in MIDAS environment) which fills two columns of the digitized version of the ESO-LV catalogue (the MIDAS table PCAT): column #102 which contains A_B 'per galaxy' and column #105 which contains the average A_B per plate. It is distributed, on request, by the data archivist of ESO.
3. An ASCI file which contains three columns: R.A., Decl. and A_B for every of 10930 galaxies. It is distributed, on request, by J. Chołoniewski (Astronomical Observatory

of the Warsaw University, Aleje Ujazdowskie 4, 00-478 Warszawa, Poland) on 5.25 or 3.5 floppy disc.

Figure captions

Fig.1 Surface brightness (measured at the effective isophote) of ESO-LV galaxies in B and R bands.

Fig.2 The idea of extinction measurements using the surface brightness of galaxies in two bands.

Fig.3 The map of the relative extinction in the B band in polar equatoria coordinates. Our results for extinction have been averaged inside $3^{\circ} \times 3^{\circ}$ pixels and are displayed here using $1.5^{\circ} \times 1.5^{\circ}$ pixels – some interpolation have been applied to fill pixels without data ($\sim$ 5% of total). The credibility of apparent structures can be assessed by using the following information: the uncertainty of A_B inside one resolution element (inset box at the lower right) is 0.13^m, roughly corresponding to the step of one colour on the map. The zero point is somewhat arbitrary, but a lower limit could be deduced by avoiding negative extinctions in regions with a minimum extinction (*not* at the South Pole) and a deconvolution of the observed frequency distribution of A_B with the measurement error function.

EDITOR:
If colour picture on cover ten renumber figures
$3- > 1$
$1- > 2$
$2- > 3$
and refer to new fig 1. at the end of section Introduction.
Please take care of renumbering old 1 and 2 in section The Technique
and old 3 in section The map
Thank you.