ON GALACTIC ABSORPTION

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ABSTRACT

We show that the stellar photored magnitude, m_{10}, of the 10th by brightness galaxy in an Abell cluster is not a good indicator of the cluster distance. We find that the values of m_{10} for clusters in the southern Galactic hemisphere are systematically fainter by about $0^{\mathrm{m}}17$ than those in the northern hemisphere. This may be due to higher absorption of objects in the south Galactic hemisphere or to atmospheric extinction in observations of clusters in high zenith angles.

Key words: dust, extinction – galaxies: clusters: general – solar neighborhood

1. INTRODUCTION

The study of Galactic absorption is important for many issues related to extragalactic research. It was shown by Ambartsumian & Gordeladze (1938) that the extinction in our Galaxy is not due to uniformly distributed dust, but is concentrated in separate, patchy clouds. This idea was further developed by Schatzman (1950), Chandrasekhar & Münch (1952), and Knude (1979). Detailed cartography of the nearby interstellar clouds has shown the extreme inhomogeneity of the interstellar medium, and the existence of some paths exempt from any absorbing material over large distances (Neckel et al. 1980). The first general reddening maps of the Galaxy were published by Burstein & Heiles (1978, 1982), but more detailed and widely used maps are those of Schlegel et al. (1998), hereafter SFD. SFD constructed their reddening maps using maps of the far-infrared emission of dust and following a complex procedure, so that it is not surprising that several authors have found discrepancies when they compare these maps with independent reddening estimates (see Cambrésy et al. 2005, and references therein). Certainly, in order to achieve a good absolute calibration of reddening maps, it would be useful to have as many constraints as possible on the distribution of reddening.

In this paper, we study Galactic absorption using the data on Abell clusters of galaxies (Abell et al. 1989, hereafter ACO). We suggest that the south Galactic hemisphere is probably more obscured than the north hemisphere.

2. DATA AND RESULTS

We use the photored stellar magnitudes of the 10th by brightness galaxies, m_{10}, of the ACO clusters of galaxies with known redshifts z. Redshifts are taken from Struble & Rood (1991). We used those clusters the redshift of which were determined by means of at least two galaxies. We excluded from consideration the clusters located within the Galactic plane ($|b| < 30°$). Also, we did not include in our sample the relatively small number of clusters with $z > 0.2$. The compiled sample contains 791 clusters, 588 of which were found in the original survey (Abell 1958, hereafter A58) at declinations $\delta > -30°$ (378 and 210 clusters in the northern and southern Galactic hemispheres, respectively), and 203 clusters found by the southern survey at $\delta < -30°$.

2.1. On the Stellar Magnitude Standard of ACO Clusters

ACO studied in detail the problems arising from the different stellar magnitude standards used in the northern Palomar Sky Survey (POSS), made using 103a-E plates, and the southern portion of the survey, made using IIIa-J films. They showed that the IIIa-J films have increased sensitivity to redshift, and therefore introduced a correction to the measured magnitudes in order to unify the results of both surveys.

In Figure 1, we compare the dependence of the stellar magnitude m_{10} on redshift z for clusters located in the north Galactic hemisphere (A58), and those found in the southern Galactic hemisphere by ACO with the southern survey ($\delta < -30°$). Figure 1 shows, first, that the dispersion of z for a given magnitude of the 10th by brightness galaxy is very high. For distant clusters, the dispersion of redshifts z for a given m_{10} magnitude spans almost four-fold from about 0.05 to about 0.2. This high dispersion means that the stellar magnitude of the 10th-rank galaxy may serve only very roughly as an indicator of distance. By using these magnitudes, the distance of a cluster may be estimated more or less correctly only for nearby clusters with m_{10} brighter than $15^{\mathrm{m}}0$–$15^{\mathrm{m}}5$.

The least-squares fit lines of the northern and southern samples of clusters in Figure 1 show that in spite of the very large dispersion, the clusters located in the northern Galactic hemisphere are, on average, brighter than those of the sample of southern clusters at all redshifts. A Kolmogorov–Smirnov two-dimensional test (Fasano & Franceschini 1987) shows that the probability that the northern and southern clusters are of the same parent population is very small, $P = 2 \times 10^{-8}$. The difference between m_{10} in the two samples is small at high z and increases when z decreases, reaching, on average, $\approx 0^{\mathrm{m}}66$ at $z = 0.025$. Such a trend may be caused by the dependence of the stellar magnitude determination on redshift. This means that the correction introduced by ACO did not remove completely the dependence of sensitivity with redshift of the IIIa-J films. The stellar magnitudes of the southern ($b < -30°$) survey are biased against redshift. Therefore, in what follows we use only the data of the original Abell (1958) catalog of clusters found on the POSS 103a-E plates at declination $\delta > -30°$.

2.2. On Galactic Extinction

For our study of Galactic absorption, we compare the dependence of stellar magnitude m_{10} on redshift z for clusters located
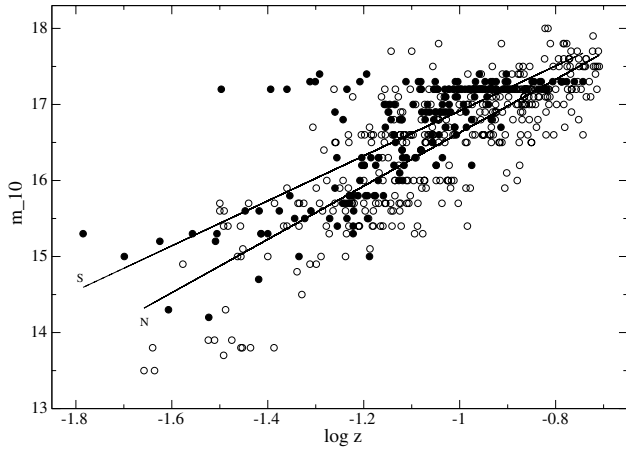
Figure 1. Stellar magnitude m_{10} of the cluster 10th-rank galaxy as a function of $\log z$ for clusters with $b > 30°$ (open circles) and $b < -30°$ (filled circles), the latter from the ACO southern survey. The solid line is the least-squares fit for the 397 northern clusters; the dashed line is for the 203 southern ones.
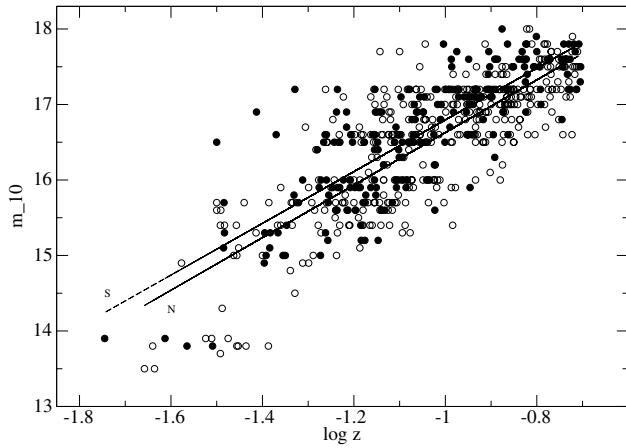

Figure 2. Dependence of the stellar magnitude m_{10} of the cluster 10th-rank galaxy on $\log z$ for clusters with $b > 30°$ (open circles) and $b < -30°$ (filled circles) found in A58. The dashed line is the least-squares fit for the 397 northern clusters; the solid line is for the 215 southern ones.
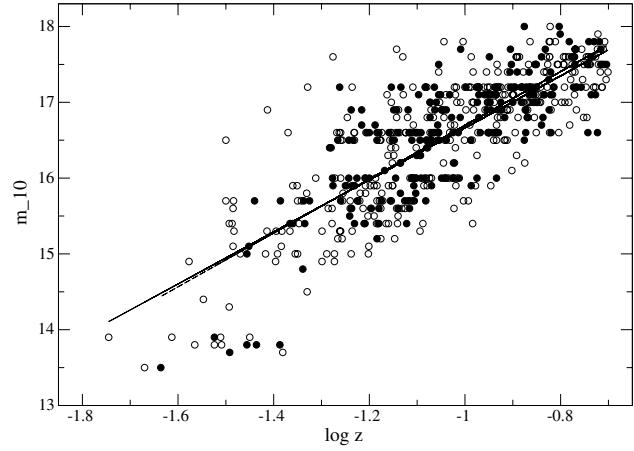

Figure 3. Dependence of the magnitude of the cluster 10th by brightness galaxy on $\log z$ for 246 clusters of the eastern hemisphere (filled circles), and 368 clusters located in the western Galactic hemisphere (open circles). The solid line is the least-squares fit for western clusters and the dashed line is for eastern clusters.
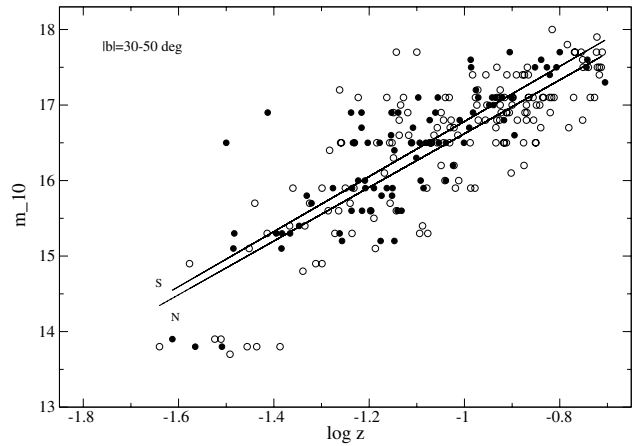

Figure 4. Dependence of the stellar magnitude m_{10} of the cluster 10th-rank galaxy on $\log z$ for clusters with $|b| = 30°–50°$. Open circles represent northern clusters and filled circles southern clusters (A58). The solid line is the least-squares fit for the 157 northern clusters, and the dashed line is that for the 88 southern ones.

in the north and south Galactic hemispheres. As we mentioned above, we use clusters which were found in the original A58 survey, and are presented in ACO. Thus, we get rid of calibration problems and the bias of magnitudes against z. We show in Figure 2 the graphs $m_{10} - \log z$ for the northern ($b > 30°$) and southern ($b < -30°$) clusters. It can be seen in this figure that the least-squares fit lines of the northern and southern samples of clusters are almost parallel to each other. The probability that both samples have the same parent population is, according to a Kolmogorov–Smirnov two-dimensional test, $P = 2.6 \times 10^{-3}$. Hence, the relative displacement between the two populations is significant. The difference between m_{10} of the northern and southern clusters is almost constant at all redshifts, and is equal, on average, to $\approx 0^{\mathrm{m}}.17$. Note that the northern hemisphere contains an area of high obscuration around $l = 300°$ (A58) due to which the mean m_{10} magnitude of the sample of northern clusters will be higher. Also, as SFD mention, the lowest column density dust holes are in the southern sky. Both these factors will tend to decrease the relative brightness of northern clusters, and thus the difference may in reality be somewhat higher.

On the other hand, there is no difference in the average absorption between the eastern ($l = 0° \pm 90°$) and western

($l = 180° \pm 90°$) Galactic hemispheres. The graphs $m_{10} - \log z$ for 246 eastern and 368 western clusters are presented in Figure 3. This figure shows that, contrary to what we found when we compared clusters observed in the northern and southern Galactic hemispheres, there is almost no difference between the distribution of eastern and western clusters in the $m_{10} - \log z$ graph: the least-squares fit lines of both populations do not differ from each other.

Hence, the faintness of the m_{10} photored magnitude of galaxies in the southern clusters is obviously due to *higher obscuration* by dust clouds in the direction of the south Galactic hemisphere. Since the photored magnitudes are close to those measured in the *R*-band, the obscuration will be higher in the *V* and *B* bands.

In order to see whether there is a dependence of the obscuration on Galactic latitude, we constructed $m - \log z$ graphs separately for clusters with $|b|$ within the ranges $30°–50°$, $50°–70°$, and $70°–90°$ (Figures 4–6). These figures show that for all three latitude ranges the 10th-rank galaxies of the northern clusters are, on average, brighter than those of the southern clusters.
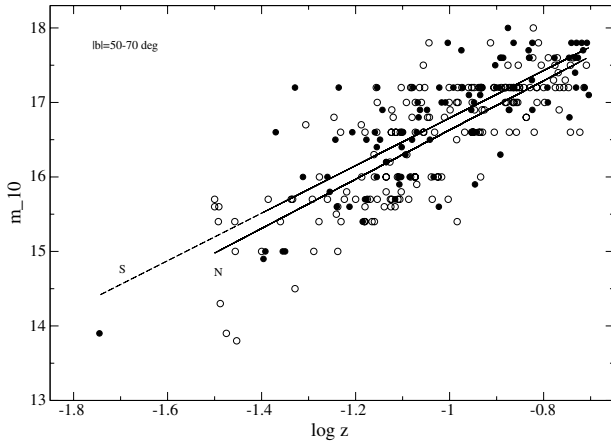
Figure 5. Dependence of the stellar magnitude m_{10} of the cluster 10th-rank galaxy on log z for clusters with $|b| = 50°–70°$. Open circles represent northern clusters and filled circles southern clusters (A58). The solid line is the least-squares fit for the 187 northern clusters, and the dashed line is that for the 95 southern ones.

Figure 6. Dependence of the stellar magnitude m_{10} of the cluster 10th-rank galaxy on log z for clusters with $|b| = 70°–90°$. Open circles represent northern clusters and filled circles southern clusters (A58). The solid line is the least-squares fit for the 54 northern clusters, and the dashed line is for the 33 southern ones.

A Kolmogorov–Smirnov two-dimensional test shows that the probability that the two populations in each of Figures 4–6 are of the same parent population is $P = 7.4 \times 10^{-4}$, $P = 7.3 \times 10^{-2}$, and $P = 0.2$. Hence, the difference in m_{10}(south) − m_{10}(north) for clusters at $|b|$ within $30°–50°$ and $50°–70°$ is significant. The significance of the difference in m_{10} for the small sample of clusters in the polar cups ($|b| = 70°–90°$) is marginal, probably because of the small statistics in these areas. The mean difference m_{10}(south) − m_{10}(north) for samples of clusters at low $|b|$, $30°–50°$ and $50°–70°$, is $0.^{m}15$ and $0.^{m}18$, respectively. The difference in m_{10} for the polar cup clusters is on average $0.^{m}35$. Though the last difference is almost insignificant, there might be a trend of increase in the difference m_{10}(south)−m_{10}(north) with Galactic latitude. At higher Galactic latitudes, the *difference* between absorption in the northern and southern hemispheres would become higher. In any case, we find that the southern Galactic sky is on average *more strongly obscured*, in apparent contradiction to the results of SFD, who find that the south Galactic sky has regions with very low dust emission. It is worth noting that several authors (see e.g. Cambrésy et al. 2005, and references therein) find that the SFD map overestimates the extinction A_V up to a factor of 2 in some specific directions. Studies such as that presented here can help in the determination of the absolute calibration of extinction maps.

3. CONCLUSIONS

We have studied the dependence of the photored stellar magnitude m_{10} of the 10th by brightness galaxy in ACO clusters of galaxies on redshift z, and show that the former is not a good indicator of distance. We also show that the stellar magnitudes of galaxies in clusters found in the southern survey at $\delta < -30°$
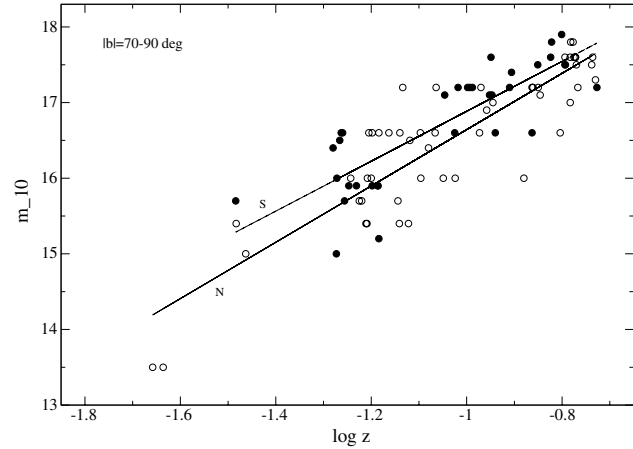
(ACO) depend on redshift and become fainter by about $0.^{m}5$ for the nearest clusters.

We find that the stellar magnitudes m_{10} of clusters located in the southern Galactic hemisphere are systematically fainter, by about $0.^{m}17$, than those of clusters in the northern Galactic hemisphere. This probably means that objects in the southern Galactic hemisphere are affected on average by higher obscuration than the northern objects. At the same time, there is no difference in absorption between the eastern and western Galactic hemispheres.

This additional extinction in the direction of the south Galactic hemisphere is probably caused by the additional path that the light of the observed objects follows before reaching the Sun, supporting the idea that the Sun is located above the Galactic plane.

The difference in absorption found between northern and southern clusters may also be due to not properly taking into account the atmospheric extinction in observations of southern clusters at high zenith angles.

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