A Comparison Between Galactic and Large Magellanic Cloud (LMC) Interstellar Extinction Curves

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Abstract

Average interstellar extinction curves for Galaxy and Large Magellanic Cloud (LMC) over the range of wavelengths (1100 A^0 – 3200 A^0) were obtained from observations via IUE satellite.
The two extinctions of our galaxy and LMC are normalized to Av=0 and E (B-V)=1, to meat standard criteria. It is found that the differences between the two extinction curves appeared obviously at the middle and far ultraviolet regions due to the presence of different populations of small grains, which have very little contribution at longer wavelengths. Using new IUE-Reduction techniques lead to more accurate result.

مقارنة بين منحنيات انطفاء الضوء للمجرة وغيمة ماجلان الكبرى

الخلاصة

تم إيجاد منحنيات الانطفاء للمادة ما بين النجوم لمجرتنا وغيمة ماجلان الكبرى لمديات الأطوال الموجية (١١٠٠–٣٢٠٠) انكستروم باستخدام المعطيات الرصدية للأقمار الصناعية (IUE) .
تمت معايرة المنحنيين ليصبح الانطفاء عند المرشح للطول الموجي المرئي (Av=0) والزيادة اللونية (E(B-V)=1) لتتوافق مع المعايير القياسية المعتمدة.
تبين في هذا البحث وجود اختلافات واضحة بين المنحنيين في المناطق الوسطى والبعيدة للأشعة فوق البنفسجية وذلك بسبب وجود جمهرة مختلفة للحبيبات الصغيرة والتي لها تأثير بسيط عند الأطوال الموجية الكبيرة.أن أستخدام تقنيات حديثة للمعطيات الرصدية (IUE-Reduction) أوصلنا الى نتائج أكثر دقة.

Introduction

Many authors have produced mean extinction curves for our galaxy based on huge number of stars exploring data obtained by space telescope in the uv-region. They have found that the general extinction law does follow a fixed curve [1, 2, 3].
For some individual objects, the extinction curves show large departures from the mean law in the scattering continuum region [4], and for the strength of the 2200 A^0 feature [5]. These variations might due to anomalies arise from the stars being peculiar, in different direction of the galaxy. Figure-1 is a typical example for these extinctions [6].

Now a day observations are available in the range of (1100-3200) A^0 via International Ultraviolet Explorer (IUE) satellite, (1330-4250) A^0 via the Orbiting Astronomical Observatory (0 A0-2) spectrophotometer system satellite and the TD-1 satellite [7]. These observatories provided data in the ultraviolet and far-ultraviolet region, where in the past; it was only the Infra-red region data the mostly available.
Extensive studied were made by exploring data supplied by these satellites on the nature of interstellar matter especially that concerning the hump near 2200 A^0 appeared in the interstellar extinction curve using reddened and unredeemed pair stars of the same spectral

type [8]. The shape of this curve is confusing, and several authors have produced mean extinction curves based on pairs of reddenedand unreddened stars. With the exception of a few individual stars, they have found no significant variations and have concluded that the general interstellar extinction law does follow a fixed curve [1, 9].

Investigations have extended for comparison between this extinction and large Magellanic cloud (LMC) curves, in order to study the variations between the two galaxies. New IUE observations confirm the differences between the Galactic and LMC ultraviolet extinction curves and show some variations within the LMC [10]. Figure (2) a typical example for LMC extinction curve compared with average extinction curve for the Galaxy [11]. It is encouraging to extend the sample taken for the Galaxy, by adding more observations carried out by IUE, looking for differences in the average extinction curves of the two galaxies in order to explain the nature of dust responsible for these extinctions.

Selection of the program stars

Sample of stars were obtained from previous and recent works using the criteria of pair matched stars of early OB-stars, in spectral type and luminosity with different (B-V) values as to give different amount of extinction.

Data for five stars observed with IUE for LMC extinction were adopted from [10], and listed in table (1). Sources for spectral type and UBV colors were adopted, [10, 11], this table tabulates the photometry for LMC chosen stars adopted. The average LMC extinction curve for these stars is shown in figure (2), plotted against the average galactic extinction curve [11].

The average galactic interstellar extinction curve, extended by adding a group of 25 (O-B) stars chosen in pairs of reddened and unreddened, observed with IUE satellite.

The program stars are listed in table (2).

These stars were observed with IUE Large Wavelength Redundant (LWR) and Short Wavelength Prime (SWP) camera.

The two spectra (SWP & LWR) were extracted and merged by using IUE-NEWSI technique; details for data reduction are mentioned by [7]. The average extinction curve for the 25 stars sample, were obtained and shown in figure (3). This figure is plotted and compared with the average galactic extinction curve obtained by [12], and both normalized to A_v=0 and E (B-V) =1.

In comparison, extinction curves for LMC and for this work are plotted together with the adopted one for the galactic plane [12], as shown in figure (4). This figure shows the differences between the three curves.

Obviously data for this work is closer to that for LMC, so that, if we extend the galactic data by adding our results obtained by this work to the average extinction data for our galaxy, the differences between LMC and the average galactic extinction curve will be reduced.

For this purpose a new galactic extinction curve are obtained and together plotted with LMC extinction curve, as shown in figure (5).

The normalization of curves was made so that:

A_v= 0, and E (B-V) =1.

Discussion and conclusion

Ever reported since 1999 [17], the Large Magellanic Cloud extinction curves has not much improved to match the galactic plane average extinction curve [18].

It is very interesting result that we obtained in this work, for the average LMC curve is nearly similar, to the average Milky Way extinction curve derived from stars reddened by dust in the diffuse interstellar regions.

Figure (5) shows that, from (3.2-4.2) μ^{-1} the two curves appeared nearly the same, while near the hump ~ (4.6 μ^{-1}), LMC data showed an access of (0.2 – 0.3) magnitudes. The 2200 A^0 profile, the extinction for LMC is wider than that for the average galactic, which indicates that a population of grains in the middle UV is larger in size are exist within LMC dust. In the far UV, the differences are nearly the same as that near the hump.

Our final comment on LMC extinction curve compared with IUE galactic extinction, that the curve obtained by this work, is useful when IUE data with improved signal –to- noise ratio of the IUE NEWSIP reduction is used and well matched comparison stars showed better results compared with previous studies.

Table 1: Sample Stars Selected From Previous Work [10].

STAR	Spectral Type	V	(B-V)	(U-V)	E_{B-V}
-70 116	B_2 Ia	12.06	0.1	-0.61	0.25
-69 108	B_3 I	12.12	0.28	-0.22	0.31
-69 7	B_9 Ia	10.5	0.18	-0.36	0.16
-66 19	B_0 I	12.8	0.13	-0.67	0.240
-67 2	$B_{1.5}$ Ia	11.27	0.11	-0.69	0.18

Table 2: Photometric Data and IUE Observation for Programmed Stars (Comparison Stars are in brackets)

STAR	Spectral Type	V	(B-V)	(U-B)	E_{B-V}	IMAGE
HD 204827[a]	B_0 V	7.95	0.80	-0.11	1.10	SWP 11131 LWR 9761
HD 239729 [a]	B_0 V	8.35	0.36	-0.54	0.66	SWP 13451 LWR 10114
BD- 41 7743 [a]	B_0 V	9.79	0.26	--	0.51	SWP 17909 LWR 14139
HD 40893[b]	B_0 V	8.90	0.16	-0.78	0.46	SWP 15682 LWR 12103
HD 53367[b]	B_0 IV	6.96	0.43	--	0.73	SWP 8053 LWR 7021
HD 209339 [a]	B_0 IV	6.66	0.07	-0.83	0.33	SWP 13450 LWR 10113
HD (36512 [a])	B_0 V	4.61	-0.26	-1.07	0.04	SWP 8164 LWR 9787
HD 46106 [a]	B_0 V	7.93	0.14	-0.77	0.42	SWP 13448 SWP 14777 LWR 10111 LWR 11364 LWR 10111
HD 38131 [b]	$B_{0.5}$ V	8.19	0.12	-0.69	0.49	SWP 15680 LWR 12102
(HD 55857)	$B_{0.5}$ V	6.12	-0.22	-0.99	0.06	SWP 14339 LWR 10953
BD + 56 545[c]	$B_{0.5}$ V	8.96	0.32	-0.54	0.58	SWP 9924 LWR 8635
BD + 54 494[c]	B_1 V	8.08	0.06	-0.79	0.32	SWP 7097 LWR 6034
BD + 55 494[c]	B_1 V	10.50	0.03	-0.70	0.29	SWP 7095 LWR 6029
BD + 59 374 [c]	B_1 V	9.68	0.40	-0.45	0.66	SWP 7089 LWR 6031
BD + 60 608 [c]	B_1 V	6.80	0.23	-0.63	0.49	SWP 9920 LWR 8631
HILTNER 188 [c]	B_1 V	9.96	0.43	-0.40	0.69	SWP 7096 LWR 6032
(HD 31726 [c])	B_1 V	6.14	-0.22	--	0.04	SWP 8165 LWR 7098

HD 14250 [a]	$B_{0.5}$ V	8.96	0.32	-0.54	0.58	SWP 16405 SWP 16406 LWR 12656 LWR 12657
HD 13338	B_1 V	9.03	0.29	-0.55	0.51	SWP 15676 LWR 12098
HD 197512 [a,b]	B_1 V	8.56	0.06	-0.69	0.32	SWP 14523 LWR 11184
HD 217979 [a]	B_1 V	8.59	0.39	--	0.61	SWP 17177 LWR 13459
BD- 41 7736 [a]	B_1 V	10.2	0.26	--	0.56	SWP 17131 LWR 13421 LWR 9770
HD 37903 [a]	$B_{1.5}$ V	7.82	0.11	-0.6	0.36	SWP 14572 LWR 11162
(HD 74273 [a])	$B_{1.5}$ V	5.90	-0.22	-0.91	0.03	SWP 14307 LWR 10938
HD 37367 [a]	B_2 V	5.95	0.16	-0.51	0.40	SWP 15085 LWR 11610
HD 170 740 [a,b]	B_2 V	5.72	0.24	--	0.48	SWP 14529 LWR 11103
(HD 64802 [a])	B_2 V	5.49	-0.20	-0.74	0.04	SWP 14308 LWR 10939
HD 147701	B_5 V	9.35	0.57	-0.08	0.73	SWP 13443 LWR 10105
(HD 34759 [a])	B_5 V	5.22	-0.15	-0.57	0.01	SWP 15537 LWR 9868
HD 191765 [d]	WN 6	8.08	0.00	-0.44	0.50	SWP 7161 LWR 6161
HD 192 163[d]	WN 6	7.50	-0.01	-0.37	0.50	SWP 4309 LWR 8478
(HD 50896 [c])	WN 5	6.90	--	--	0.00	SWP 10108 LWR 8788

Spectral Type and UVB Values were taken from:

(a) Kenedy (1973):[13]

(b) Nicolet (1978) : [14]

(c) Hiltner (1956) : [15]

(d) Spectral Type, E (B-V) from Smith (1968) : [16]
UBV Values from Kenedt (1973): [13]

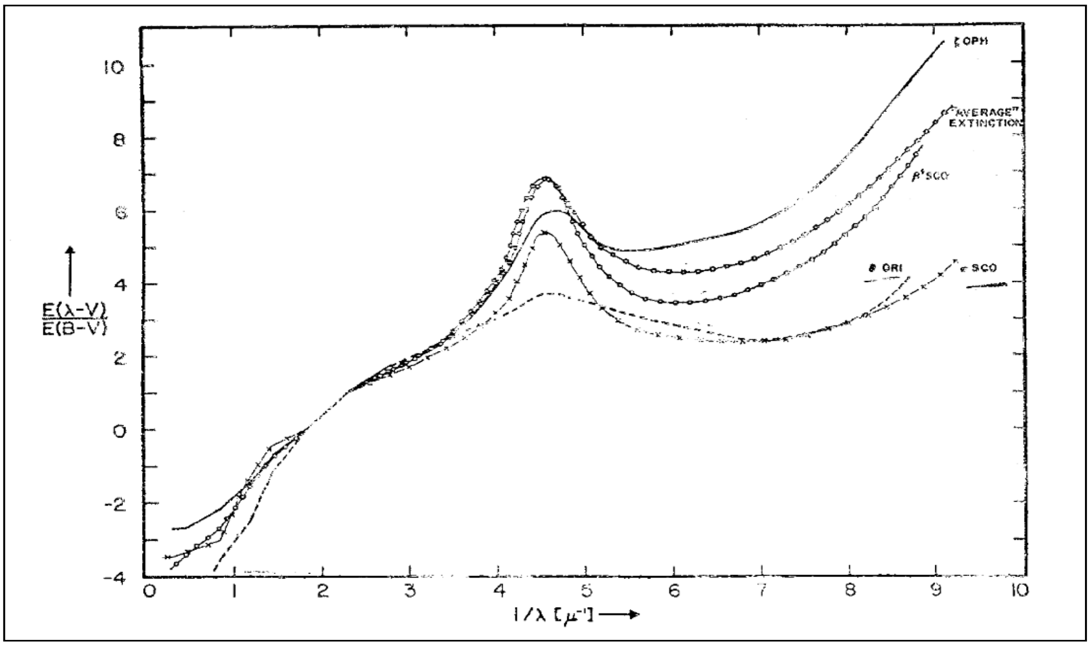

Fig 1: Interstellar Extinction Curves for different direction in the galaxy, compared with the average Interstellar Curve [6].

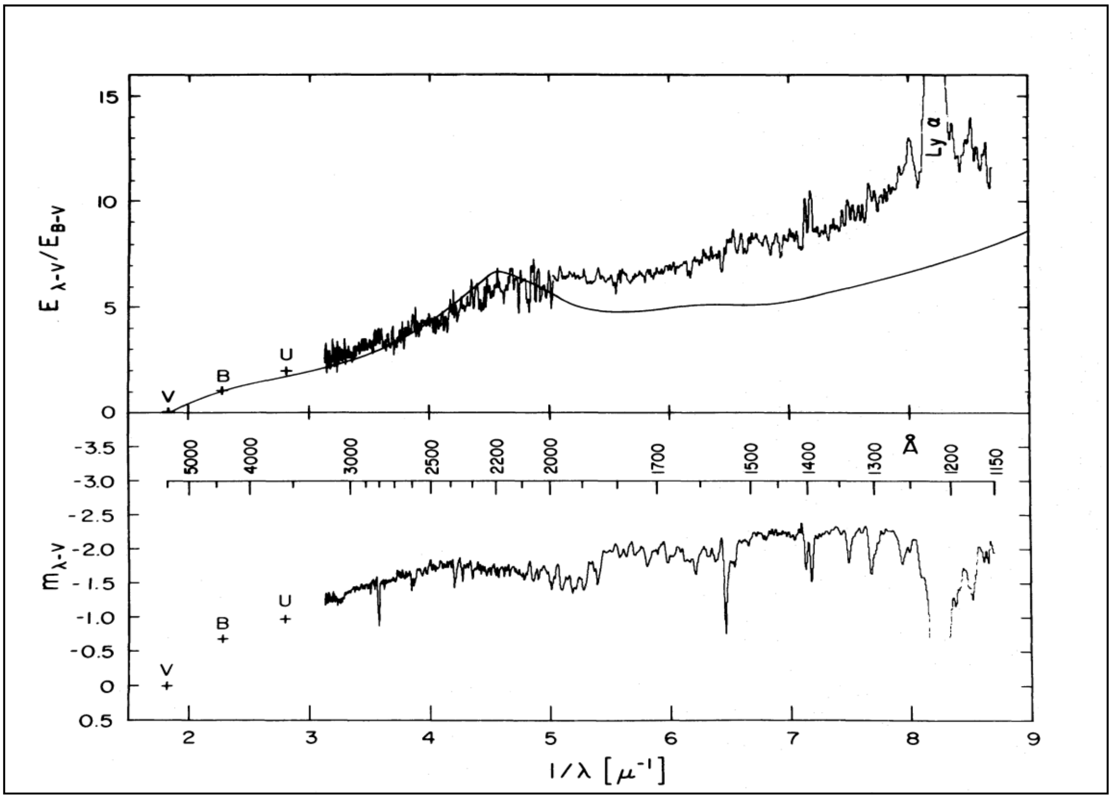

Fig 2: Extinction Curves for LMC Compared with the average Galactic Interstellar Curve [11].

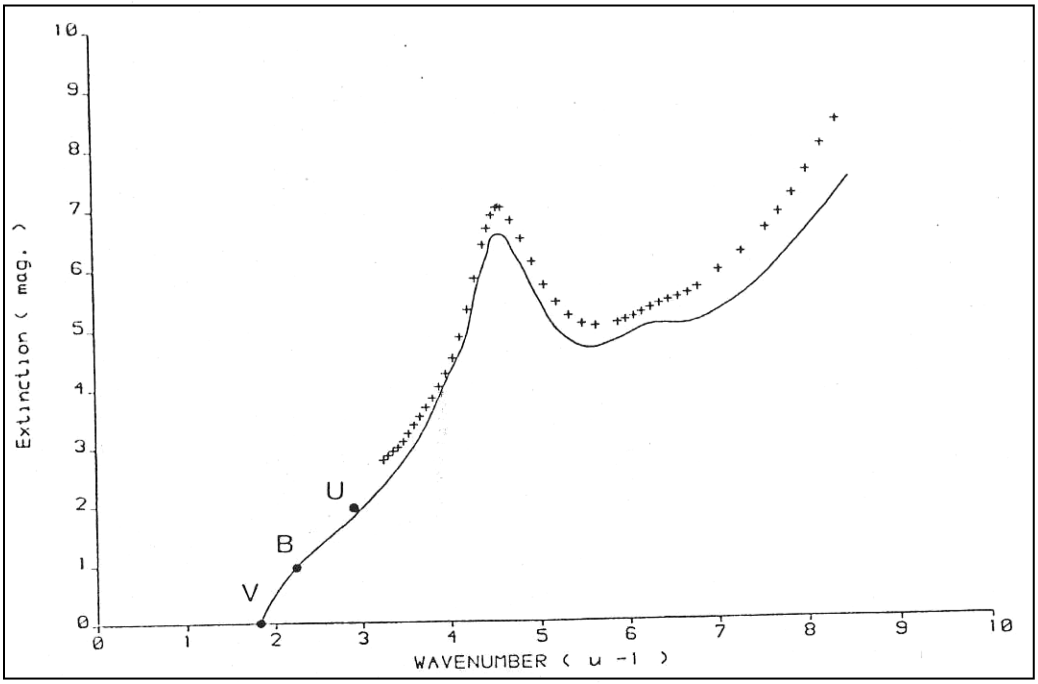

Fig 3: Average extinction curve for 25 merged SWP and LWR spectra of this work (pluses). Compared with galactic average extinction curve (Solid) [12] .the two curves were normalized to Av =0 and E(B-v) =1 . The UBV values are show on figure.

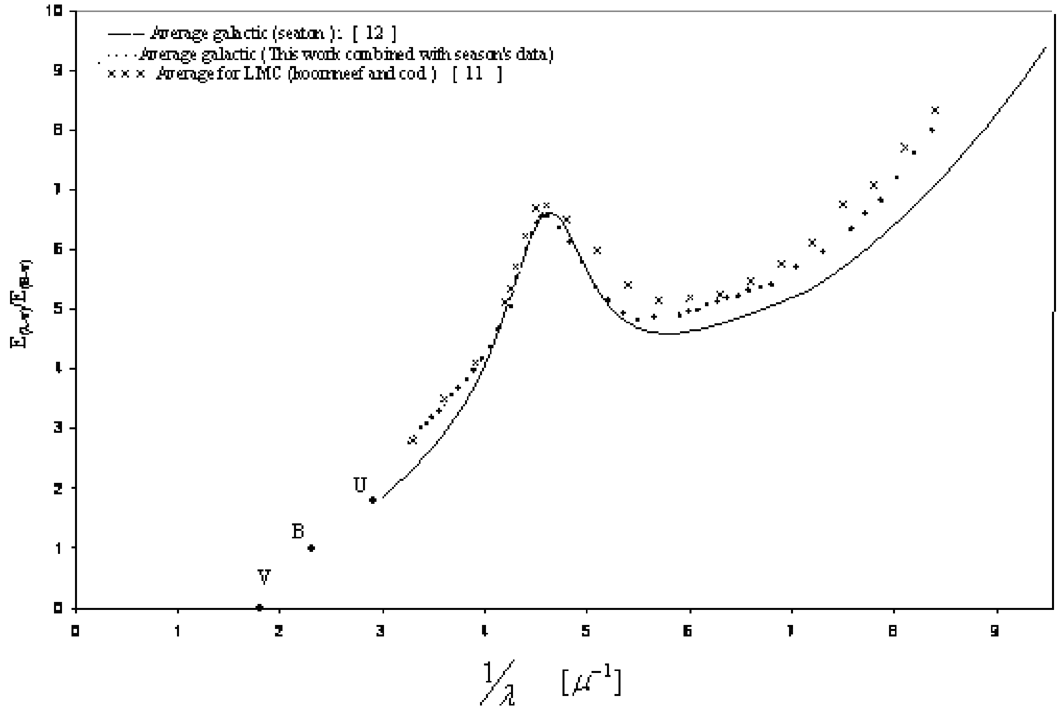

Fig 4: Combined average galactic Extinction curve for this work, and for Seaton's (dots), Compared with average (LMC) extinction curve (crosses) for Reference[11], and for Seaton's (Solid) [12] . The UBV values are shown on figure.

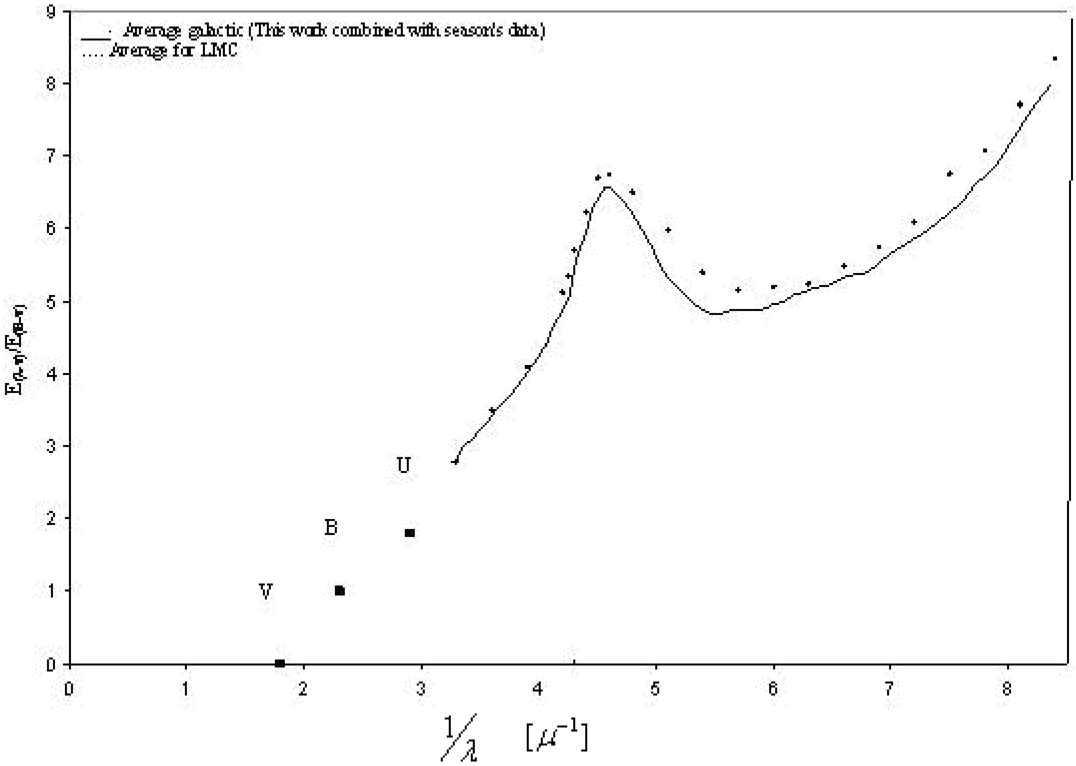

Fig 5: The combined average extinctions curve for this work and for Seaton's (solid) plotted with average for LMC [12].

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