The optical extinction law and distance estimation of the supernova remnant S147

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Introduction

In addition to asymptotic giant branch stars evolved from low- and intermediate-mass star, supernovae are an important contributor to interstellar dust. (Maiolino et al. 2004; Gomez 2012)

Parts of dust formed in the explosive ejecta of supernovae remain in the SNR, causing greater extinction than its vicinity. With this characteristic, we can derive the SNR's extinction law and distance.

S147 (G180.0−1.7) is an optically faint shell-type SNR located in the direction of the Galactic anti-center. It is highly filamentary and has a radius of 83′ (Sofue et al. 1980). It's believed to be one of the oldest SNRs with well defined shell structure. Its distance has been extensively studied by various methods and the results can be illustrated as follow:

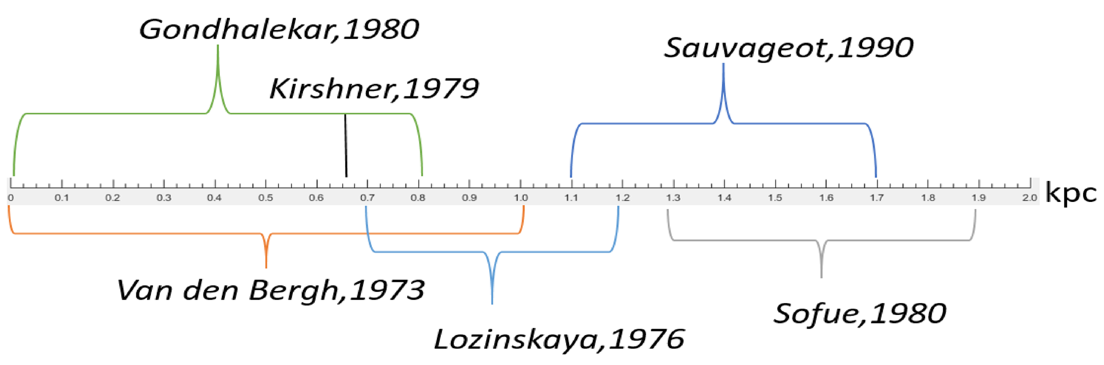

Figure 1. Previous work of distance estimation of S147

But it has never been studied based on the variation of the extinction law in and out of the SNR.

Data

1.LAMOST DR3
The Large Sky Area Multi-Object fiber Spectroscopic Telescope
2.APASS DR9
The AAVSO Photometric All-Sky Survey

These two catalogues are cross-identified with each other by the position error less than three arcsecs. This leads to a catalogue of 2504912 stars that contain observed magnitudes in BVgri bands and stellar parameters T_{eff}, log g and [Fe/H].

Then reductions are made to these data to control their quality and type. Conditions are as follows:

A. $4000<T_{eff}<8400$
B. $0<T_{eff}$-err<300
C. log>4
D. 0<log-err<0.5
E. -0.5<[Fe/H]<0.5
F. Bvrgi magnitude >0
G. 0< BVrgi–err<0.05
This leaves us 138668 qualified dwarf stars.

Methods

1. Determine the intrinsic color index(CI)
   Ducati et al. (2001) suggest that the stars around the blue edge in the Teff − $CI_{\lambda_1\lambda_2}$ diagram have the smallest extinction. So we fitted the bluest envelope of the CI with Teff to determine $CI_{\lambda_1\lambda_2}$ by Teff mathematically.

2. Extinction and color excess
   color excess $E(B-V)=(B-V)_{ob}-(B-V)_{in}$
   $A_V=R_V*E(-V)$
   The average value of R_V, 3.1, is taken for rough estimation.

2. Distance estimation
   This part can be easily done by applying the distance module formula:
   $M_V=m_V+5-5lg(r)-A_V$
   The only difficulty left is the absolute magnitude, which can be credibly derived from effective temperature for dwarfs, since their M_V are closely related to temperatures. We can derive this empirical formula by fitting the parameters given by *Allen's Astrophysical Quantities.*

Results

We are kind of stuck in the step of fitting the intrinsic color index with effective temperature. The results don't go well as we expected.

CI relations of B-V, B-i, V-i, r-i, g-i are fitted. However, due to space limit, only B-i and its residuals are presented in Figure 1 and Figure2

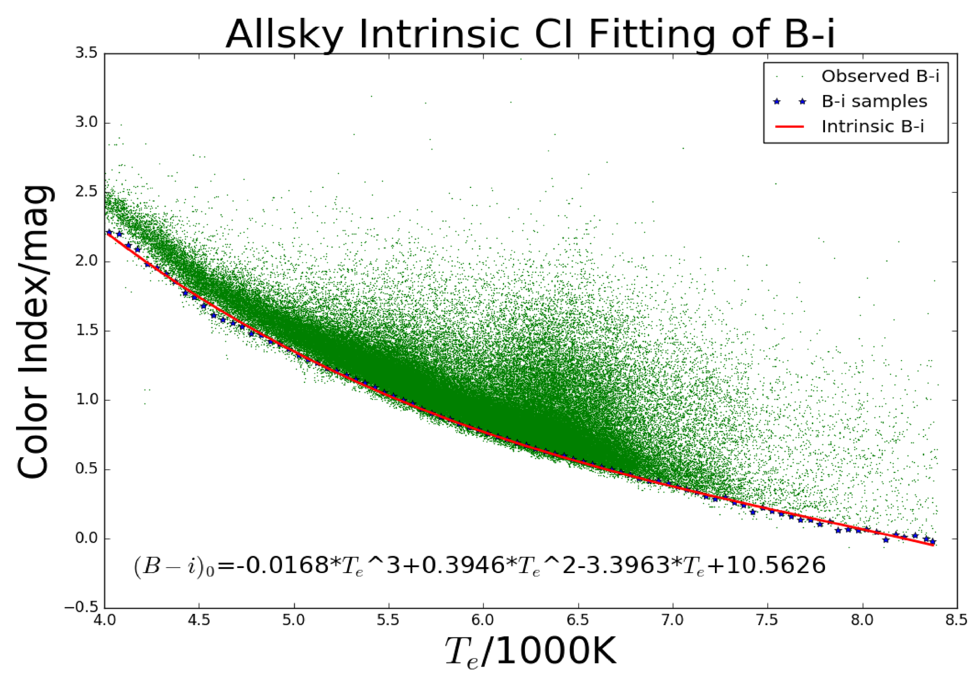

Figure 1. Intrinsic color index fitting of band B - band i

As we can see from these pictures, the fitting doesn't work well in the low temperature region. And to testify the extinction in S147 whether is different with that of its surrounding environment, we plotted the color excess ratios, which can indicate the characteristic of extinction law of dust, of S147, surroundings and all-sky in Figure 3, 4, 5 and compared them in Figure 6. The rest of results are present in Table 1

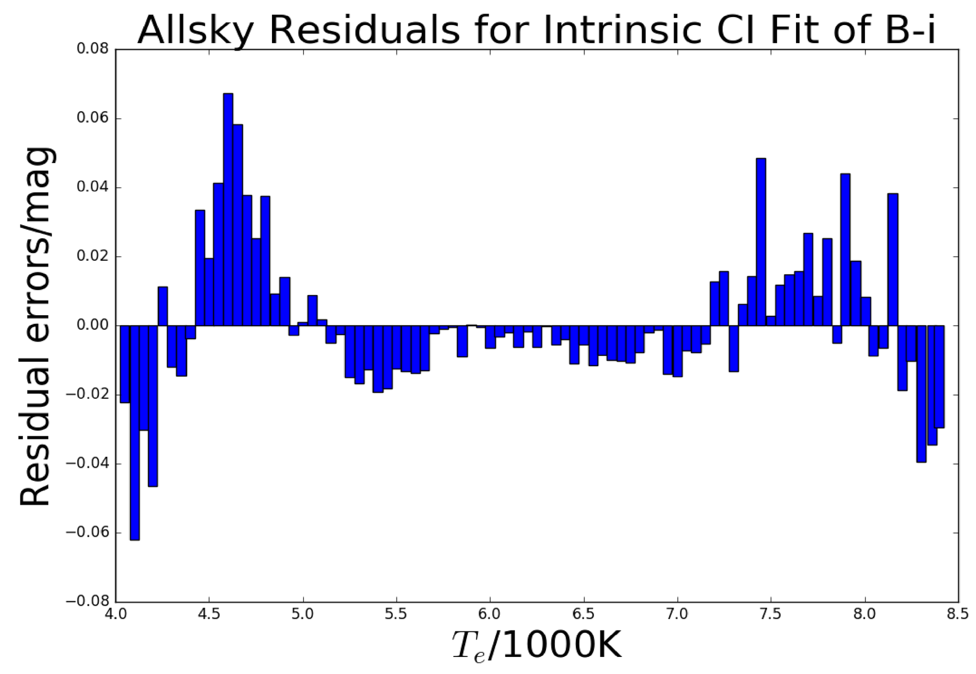

Figure 2. The residual errors of intrinsic CI of band B - band i

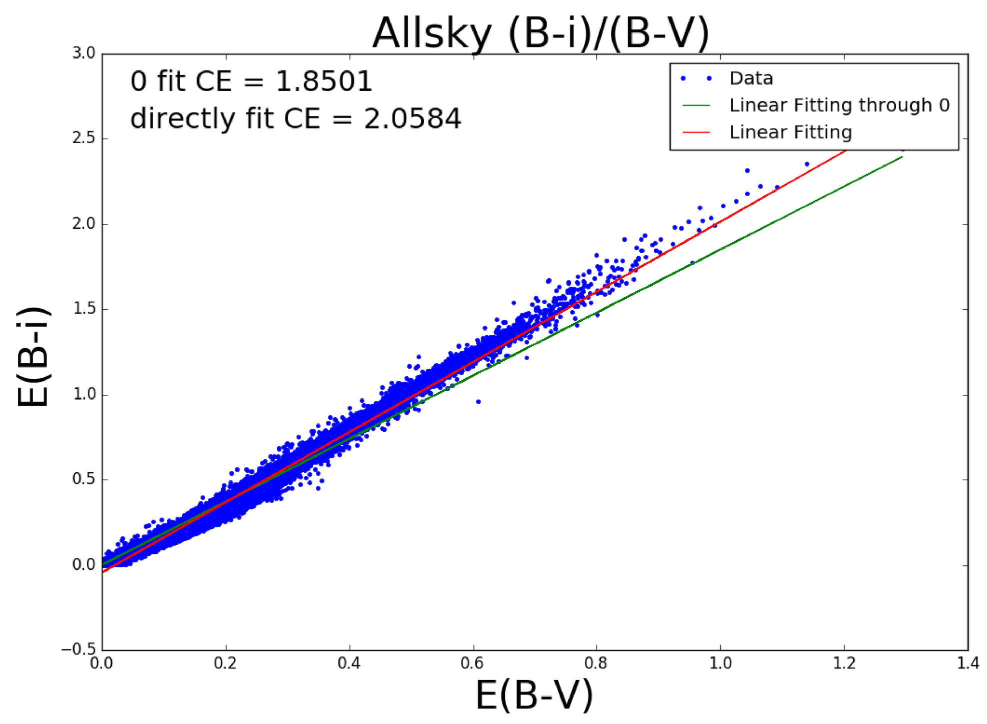

Figure 3. Color excess ratio between E(B-i) and E(B-V) in ALLSKY

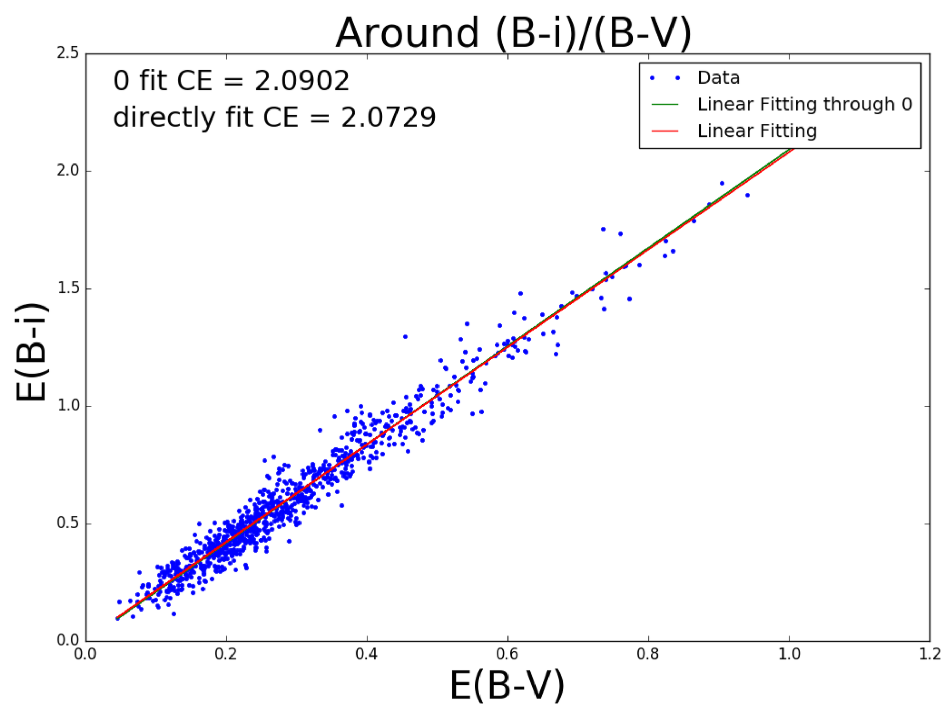

Figure 4 Color excess ratio between E(B-i) and E(B-V) around S147 from 2.5 to 5 degrees away from S147's center

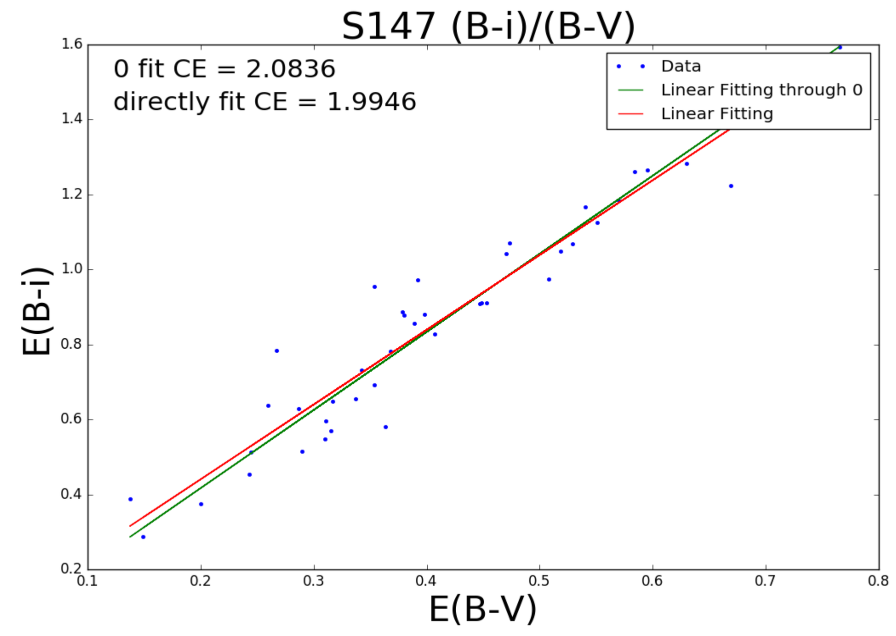

Figure 5. Color excess ratio between E(B-i) and E(B-V) in S147

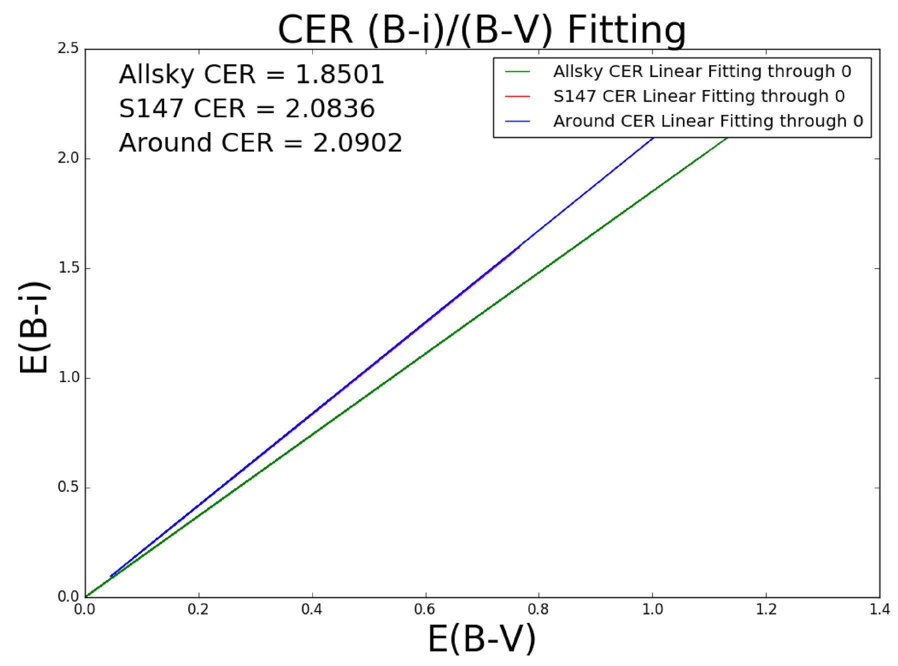

Figure 6. Comparison of color excess ratio between E(B-i) and E(B-V) in three regions

	ALLSKY	AROUND S147	S147
E(B-i)/E(B-V	1.8501	2.0902	2.0836
E(V-i)/E(B-V)	1.0377	1.1741	1.1509
E(g-i)/E(B-V)	1.5438	1.7046	1.6747
E(r-i)/E(B-V)	0.6785	0.6990	0.6793

Table 1. The CER among 4 bands in three regions

Future plans

First, as we can see from the figures, it's obvious that the fitting is poor and an improvement of fitting is necessary in the future.

Second, a lot of data are filtered, but the error distribution is not clear enough. Being specific on this problem, may help to improve the quality control and improve the fitting effect.

Third, for now, wo have just considered the dwarf, which mostly available at a short distance due to the high extinction in optical bands. But the high luminosity of giant stars may help them survive. So including giants into consideration will hopefully provide more information.

In this case, absolute magnitude cannot be easily obtained by the experimental empirical formula. Thus we have planed to utilize stellar evolution tracks calculated by PARSEC(The PAdova and TRieste Stellar Evolution Code) with a wide range of stellar parameters to determine the M_V of stars more precisely.

References

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