Ultraviolet extinction of a few supernova remnant

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Outline

- Background
- Data
  - GALEX
  - Other data: APASS, RAVE, APOGEE, LAMOST
- Method
  - Determination of intrinsic color indexes NUV-B, FUV-B , FUV-NUV
  - Determination of color excess ratio
    - E(NUV-B)/E(B-V), E(FUV-B)/E(B-V), E(FUV-NUV)/E(B-V)
- Result & Discussion
- Future plan

Background

UV band

- Very sensitive to interstellar extinction in comparison to visual and infrared bands
  - **Appropriate for low-extinction SNR**
- Able to constrain the properties of sub-um-sized dust grains

UV surveys

surveyor	Wavelength (nm)	method	Year
IUE	115-198 180-320	Spectro scopy	1978-1996
FUSE	90.5-119.5	spectro scopy	1999-2007
GALEX	135-280	5-band photom etry	2003-2012
SWIFT/U VOT	170–650	spectro scopy	2004-

Supernova Remnant and Dust

- Source of interstellar dust
  - AGB stars: low- and intermediate-mass stars
  - **Supernova: high-mass stars**
    - **Dusty high-z galaxies**
    - **SN 1987A**
- Dust emission of SNR

Data

- UV photometry: GALEX/GR 6+7 (Bianchi et al. 2014)
  - FUV band(1344-1786Å)
  - NUV band(1771-2831Å)
  - AIS: 71×10^6, 20|21 mag at FUV|NUV
  - MIS:16.6×10^6, 22.7 mag
- Optical photometry:
  - APASS/DR 9: B, V, g, r, i
- Spectroscopy:
  - LAMOST/DR 3：Teff、log g、[Fe/H]
  - Others
    - RAVE/DR 4

Method

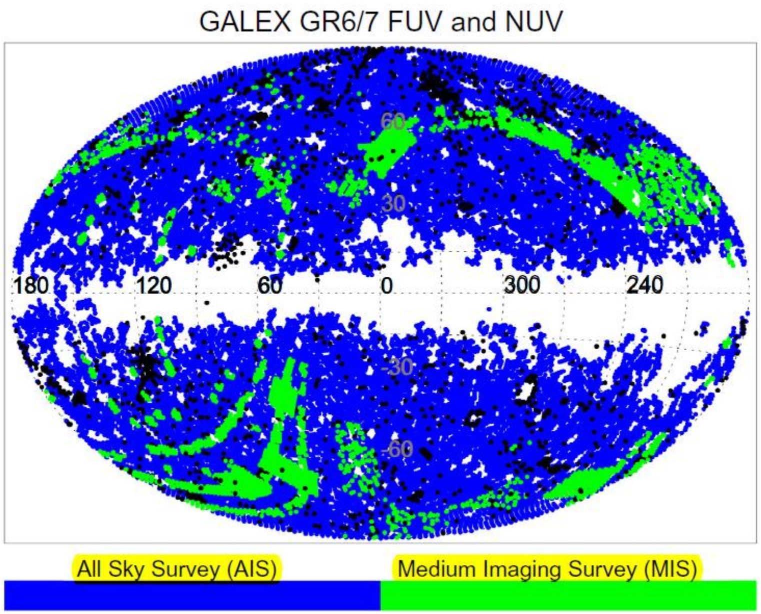
color excess: $E(\lambda_1\text{-}\lambda_2) = C_{\lambda_1\lambda_2} - C^{O}_{\lambda_1\lambda_2}$

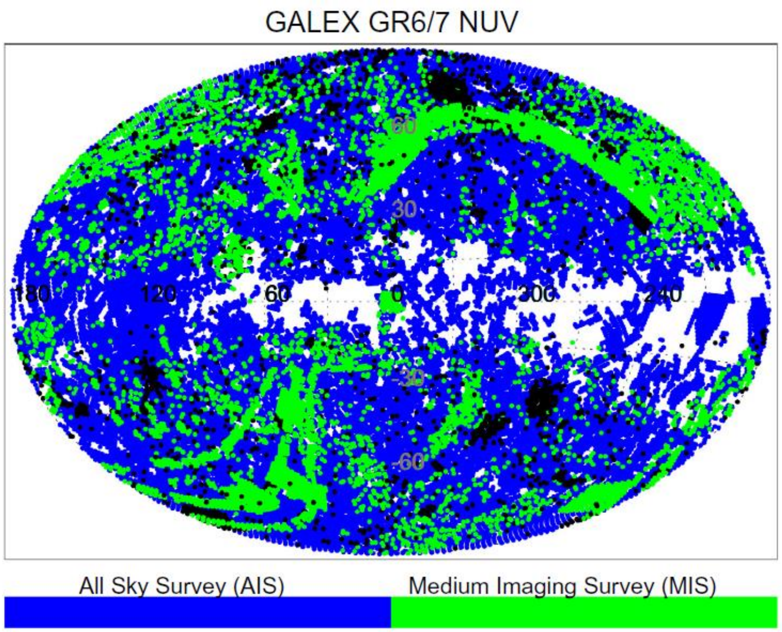
- $E(\lambda_1\text{-}\lambda_2) = A_{\lambda_1} - A_{\lambda_2}$, $\frac{A_{\lambda_1}}{A_{\lambda_2}} = ?$ $A_{\lambda_1} = ?$, $A_{\lambda_2} = ?$
- Color excess ratio
  - Extinction law
  - $\boldsymbol{\frac{E(NUV-B)}{E(B-V)}}$

The color excess ratio of all-sky UV sources

GALEX /GR6+7
APASS/DR9
RAVE/DR4(LAMOST/DR2)

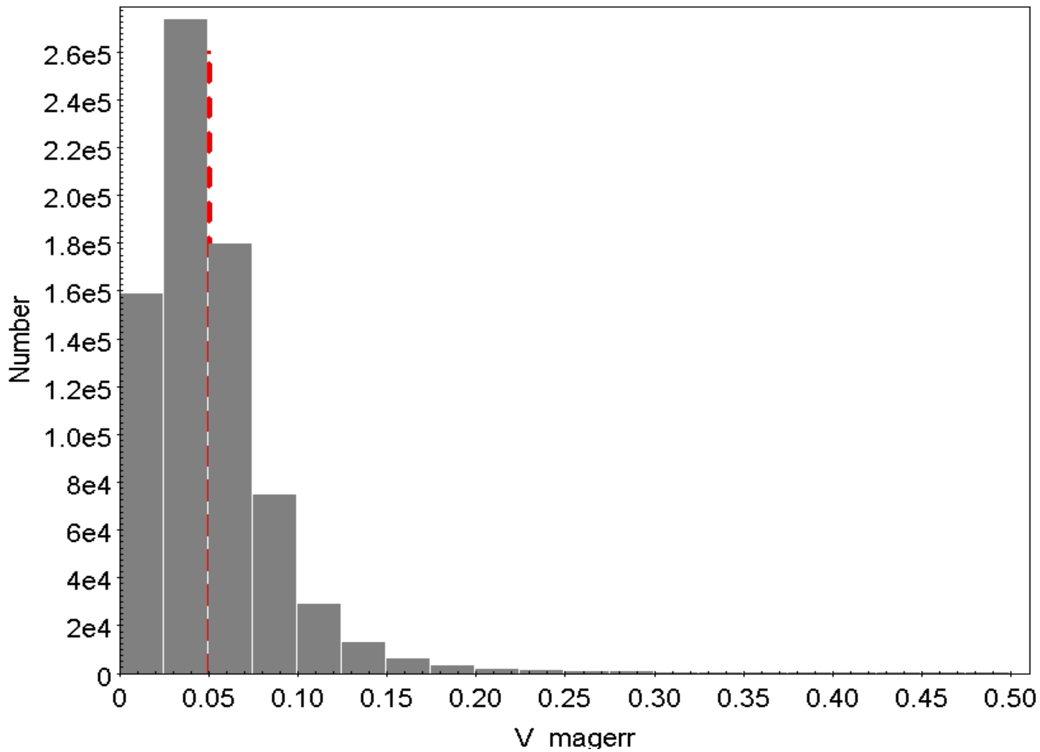
The sky cover of the GALEX sources





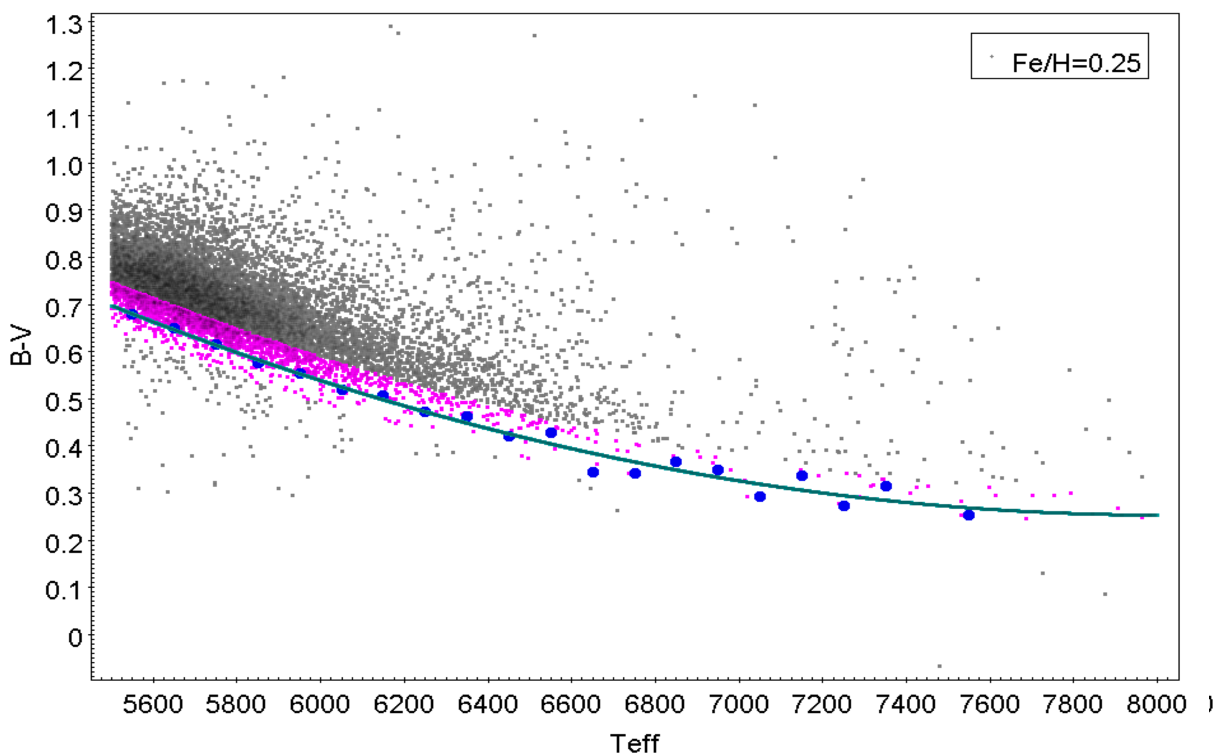
Constraints on measurement uncertainty

* σ_{Teff}<200K
* log g>4(dwarf)
* $\sigma_{\log g}$<0.3
* σ_{FUVmag}<0.3mag
* σ_{NUVmag}<0.05mag
* σ_{Bmag}<0.05mag
* σ_{Vmag}<0.05mag



Zero-reddening sources: B-V

[-0.625,-0.375]、[-0.375,-0.125]、[-0.125,0.125]、[0.125,0.375]



Relation between C_{BV}^{O} and T_{eff}: the curve of the bluest 5% : median-value: **cyan curve**

Zero extinction: The sources within 0.1mag around the curve **pink dots**

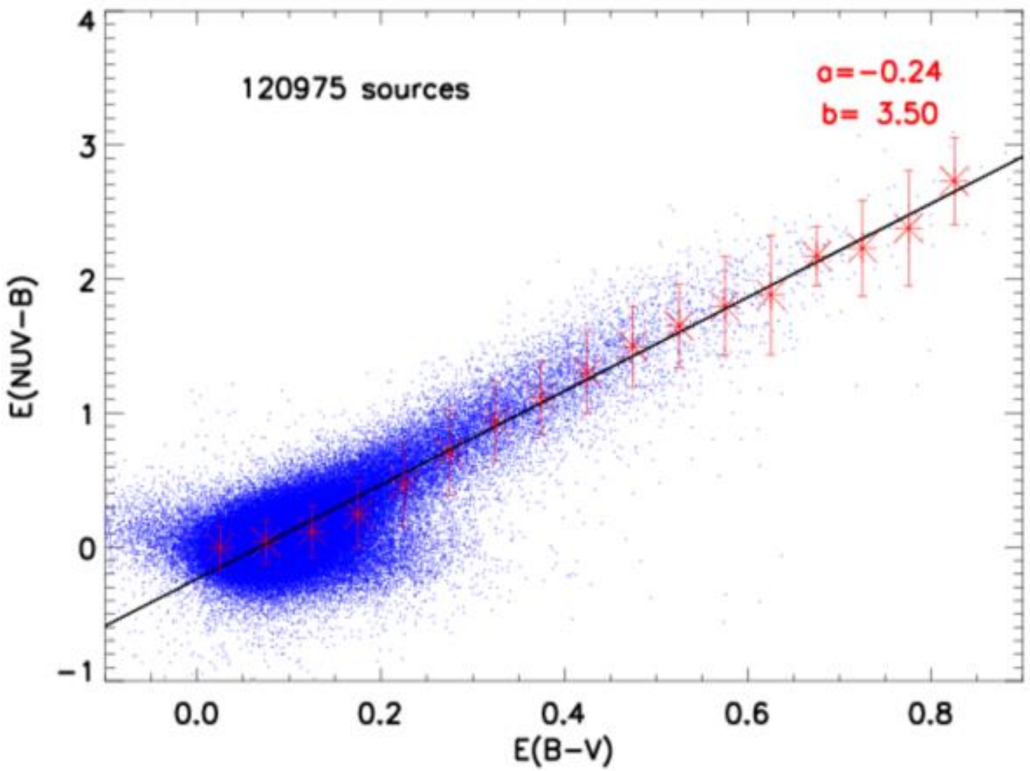
LAMOST(dwarf) vs. GALEX vs. APASS

Color excess ratio： E(NUV-B)/E(B-V)

[-0.625,-0.375]、 [-0.375,-0.125]、 [-0.125,0.125]、 [0.125,0.375]

Zero extinction:
pink dots

Relation between $C^{O}_{NUV,B}$ and T_{eff}:
cyan curve



LAMOST (dwarf)VS GALEX VS APASS

Color excess ratio ： E(FUV-B)/E(B-V)

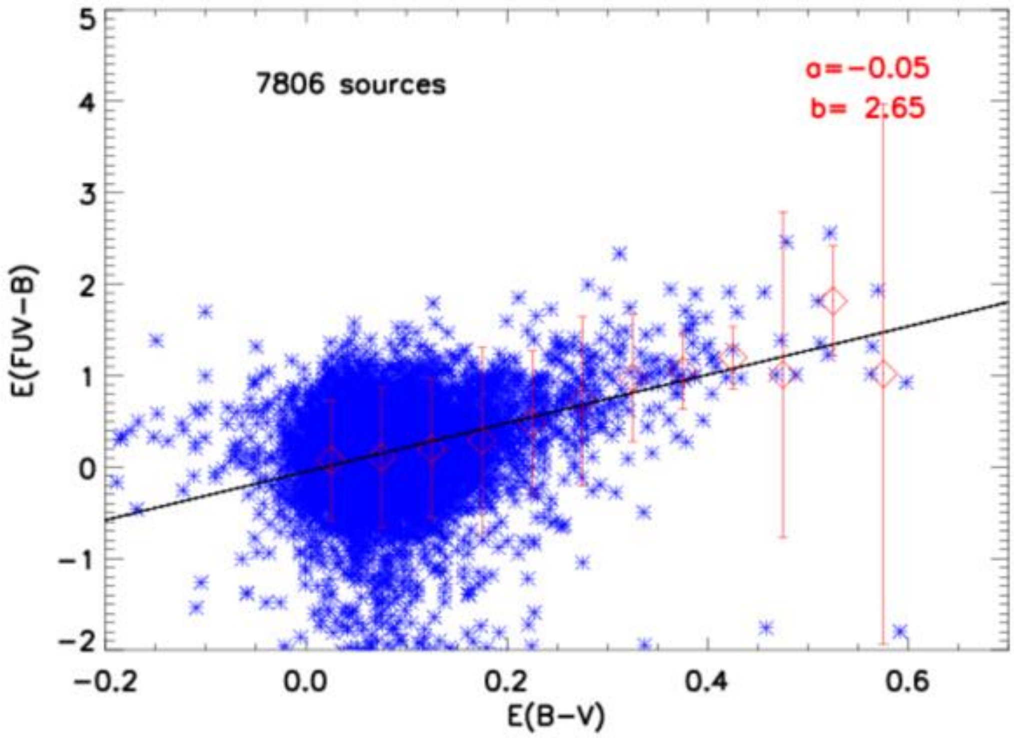
[-0.625,-0.375]、 [-0.375,-0.125]、 [-0.125,0.125]

Zero extinction:

pink dots

Relation between $C^{O}_{NUV,B}$ and T_{eff}:

cyan curve



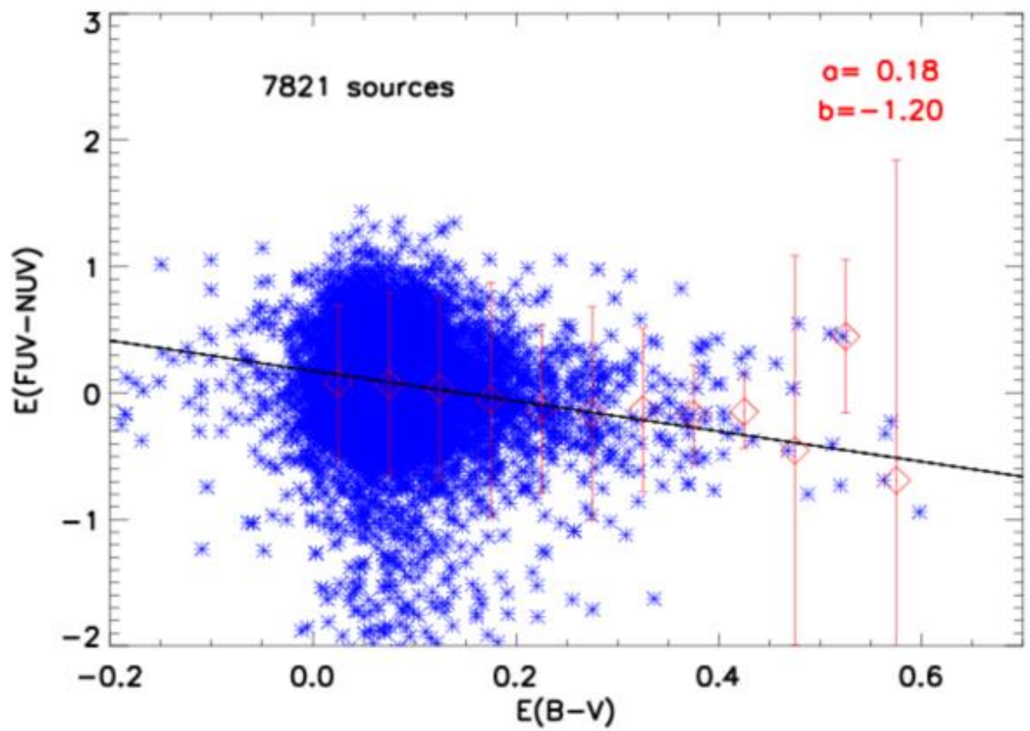
LAMOST(dwarf) vs. GALEX vs. APASS

Color excess ratio ： E(FUV-NUV)/E(B-V)

[-0.625,-0.375]、 [-0.375,-0.125]、 [-0.125,0.125]

Zero extinction:
pink dots

Relation between $C_{NUV,B}^{O}$ and T_{eff}:
cyan curve



Result & Discussion

LAMOST (dwarf)VS GALEX VS APASS

Color excess ratio

E(NUV-B)/E(B-V)	a=-0.24， b=3.5
E(FUV-B)/E(B-V)	a=-0.05， b=2.56
E(FUV-NUV)/E(B-V)	a=0.18， b=-1.2

a: intercept b: slope

? VS GALEX VS APASS

excess ratio： from other datasets

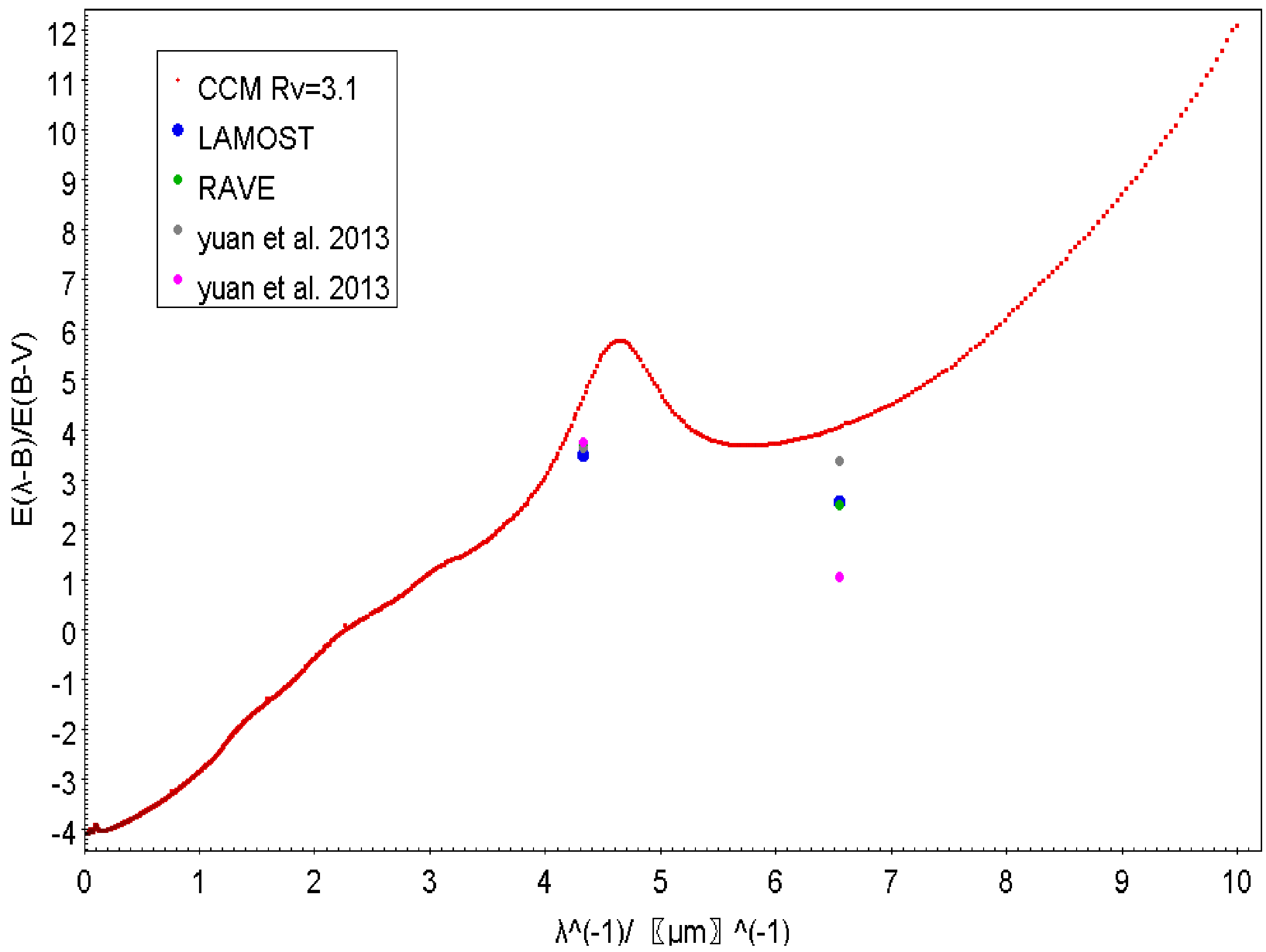
	a	b
LAMOSTNUV-B	-0.24	3.5
LAMOSTFUV-B	-0.05	2.56
LAMOSTFUV-NUV	0.18	-1.2
RAVENUV-B	-0.09	3.67
RAVEFUV-B	0.2	2.48
RAVEFUV-NUV	0.41	-1.4
Yuan 2013 NUV-g [1]		3.75
Yuan 2013 FUV-g [1]		1.06
Yuan 2016 NUV-g [2]		3.63
Yuan 2016 FUV-g [2]		3.38

a: intercept b: slope

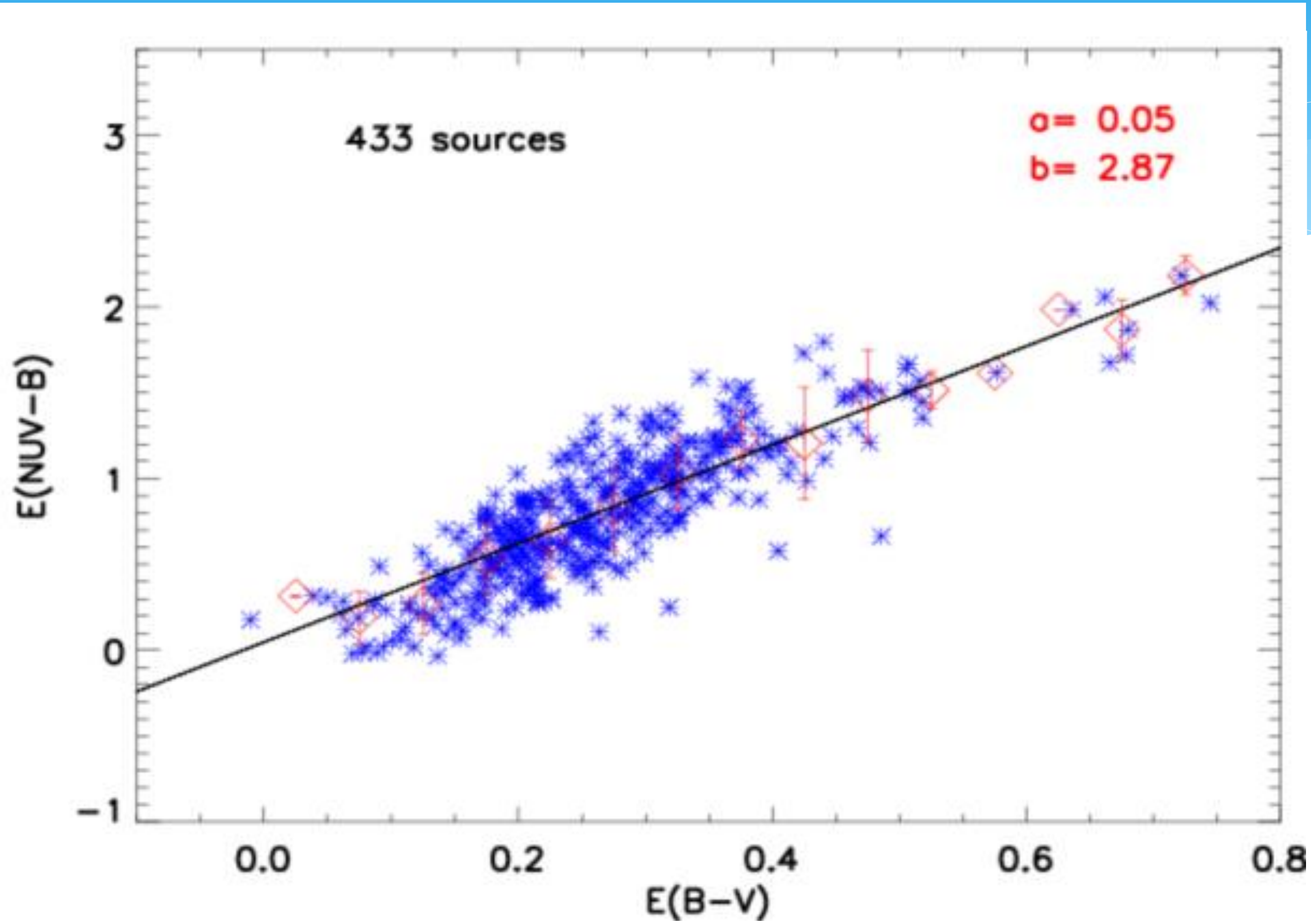
[1] yuan et al. 2013

[2] yuan et al. (2016,private communiction)

Comparison with the extinction curve



The GALEX sources -- SNR



Green (2014)

Future Plan

- Determine a better $C^{O}_{FUV,B}$
- Determine the more UV extinction of the SNRs
- Study the dust properties of the SNR dust