

# Characterizing Dust Attenuation in Local Star-Forming Galaxies: Near-Infrared Reddening and Normalization

Battisti, Calzetti, and Chary, accepted in ApJ

## Abstract & Introduction

We characterize the near-infrared (NIR) dust attenuation for a sample of  $\sim 5500$  local ( $z \lesssim 0.1$ ) star-forming galaxies and obtain an estimate of their average total-to-selective attenuation  $k(\lambda)$ . We utilize data from the United Kingdom Infrared Telescope (UKIRT) and the Two Micron All-Sky Survey (2MASS), which is combined with previously measured UV-optical data for these galaxies. The average attenuation curve is slightly lower in the far-UV than local starburst galaxies, by roughly 15%, but appears similar at longer wavelengths with a total-to-selective normalization at V-band of  $R_V = 3.67^{+0.44}_{-0.35}$ . Under the assumption of energy balance, the total attenuated energy inferred from this curve is found to be broadly consistent with the observed infrared dust emission ( $L_{\text{TIR}}$ ) in a small sample of local galaxies for which far-IR measurements are available. However, the significant scatter in this quantity among the sample may reflect large variations in the attenuation properties of individual galaxies. We also derive the attenuation curve for sub-populations of the main sample, separated according to mean stellar population age (via  $D_n4000$ ), specific star formation rate, stellar mass, and metallicity, and find that they show only tentative trends with low significance, at least over the range which is probed by our sample. These results indicate that a single curve is reasonable for applications seeking to broadly characterize large samples of galaxies in the local Universe, while applications to individual galaxies would yield large uncertainties and is not recommended.

- GALEX+SDSS で可視の減光曲線を求めた Battisti et al. (2016) の結果を近赤外線まで拡張
- **良いニュース:** 平均的には近赤外線まで universal な減光曲線が存在する
- **悪いニュース:** エネルギーの収支が合わない  $\Rightarrow$  ダストの geometry? 減光曲線は universal でも individual には適用しないほうが良さそう

## Introduction

- 星形成の盛んな  $z \sim 1-3$  ではダストに埋もれた銀河が多い  $\Rightarrow$  減光曲線とその多様性の理解は重要
- 減光曲線に関する観測的困難: ① intrinsic SED ( $\equiv$  星形成史) との縮退 ② 銀河内の光源・ダスト分布の影響
- ①, ② を克服するにはサンプル数を増やして統計で殴る手法が有効
- Battisti+ (2016) では近傍の星形成銀河およそ 9800 天体より紫外-可視の減光曲線を得た
  - 減光量の波長依存性は平均的には紫外から可視まで universal な関係が成立する
  - 星質量や星形成効率, および年齢との相関は見られないがばらつきが大きく individual には適用しづらい
- 本論文では Battisti+ (2016) の結果を近赤外線に拡張する

## Observations

- GALEX (FUV & NUV) + SDSS (ugriz + spec.) でおよそ 9800 天体 (Battisti+2016)
- 上記に UKIRT の UKIDSS Large Area Survey と 2MASS の測光データを合わせる  $\Rightarrow$  およそ 5500 天体

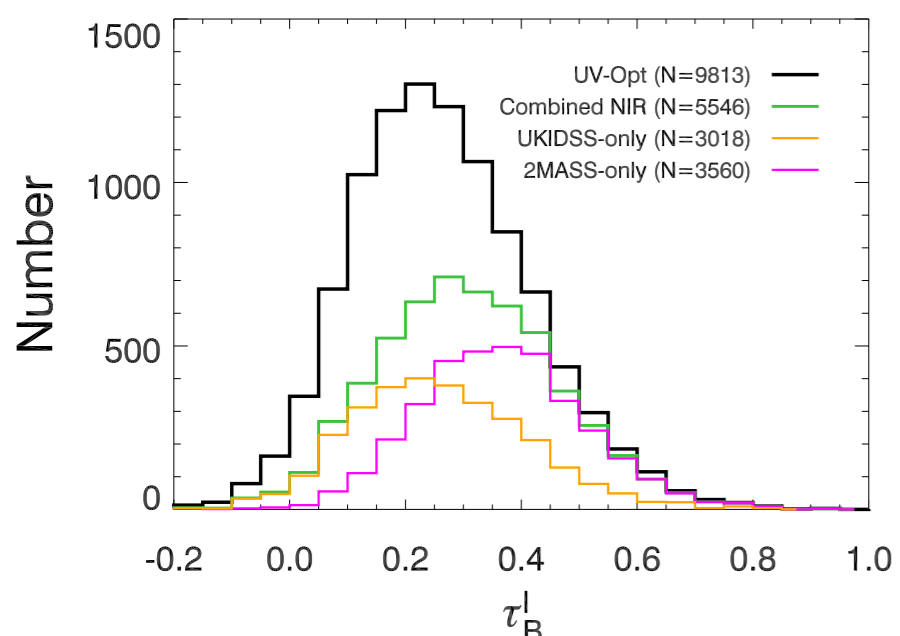


Figure 1. Distribution of Balmer optical depths,  $\tau_B^l$ , a probe of dust content in galaxies, for the UKIDSS LAS (orange line) and the 2MASS (magenta line) samples compared to the parent sample selected in the UV-optical (black line; Battisti et al. 2016).

$$k(\lambda) = A_\lambda / E(B - V)$$

total-to-selective extinction

$$\tau_B^l = \tau_{H\beta} - \tau_{H\alpha}$$

Balmer decrement (水素輝線強度比で測った減光量)

### 注意

Broad band filter での測光は主に星からの光を見ている  
輝線は星形成領域から出ているのでガスに対する減光則が適用  
SED 解析のために補正したいのは星に対する減光則である  
ざっくりオーダーで評価すると以下のとおり (Calzetti+2000)

$$\langle E(B - V)_{\text{star}} \rangle \simeq 0.5 \langle E(B - V)_{\text{gas}} \rangle$$

## Figure 2: テンプレート SED

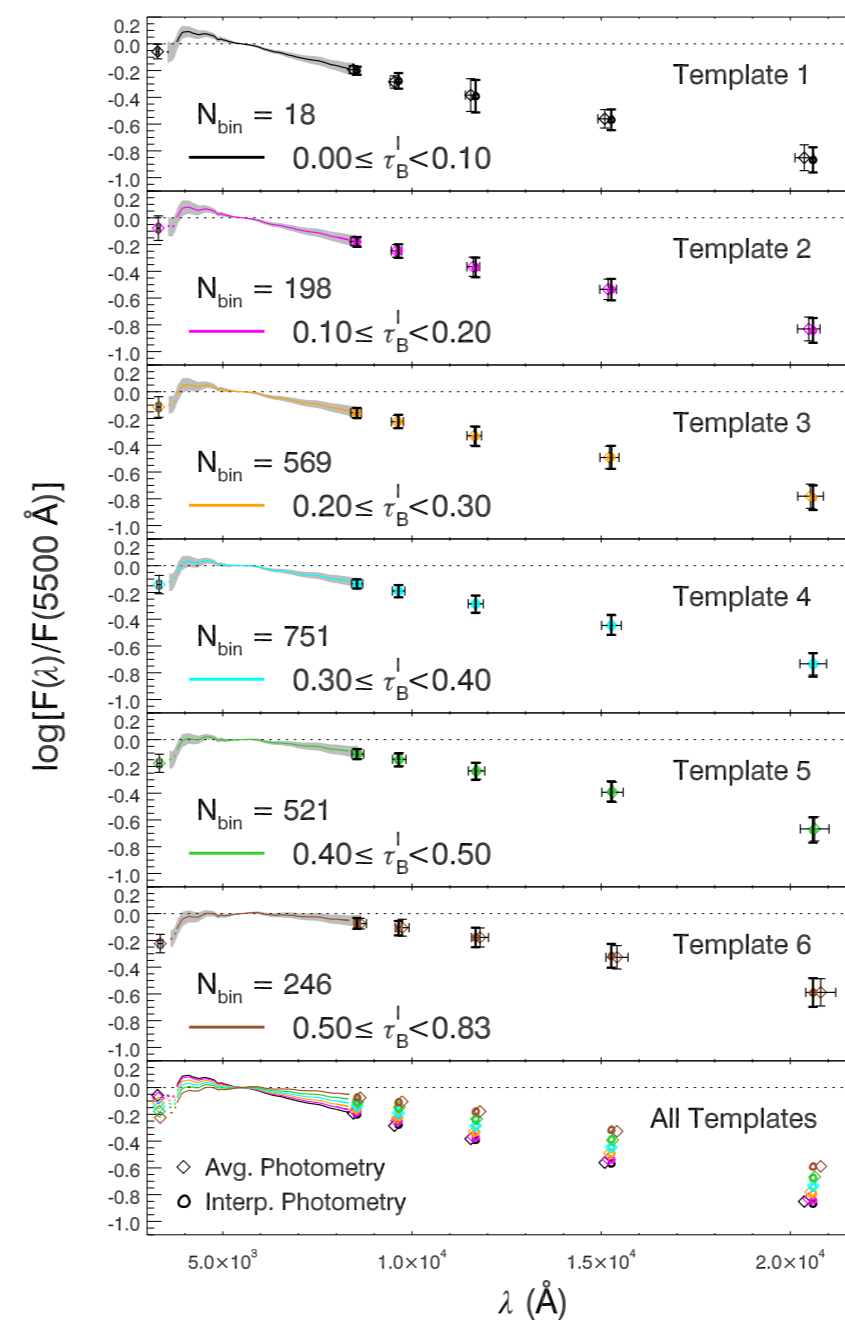
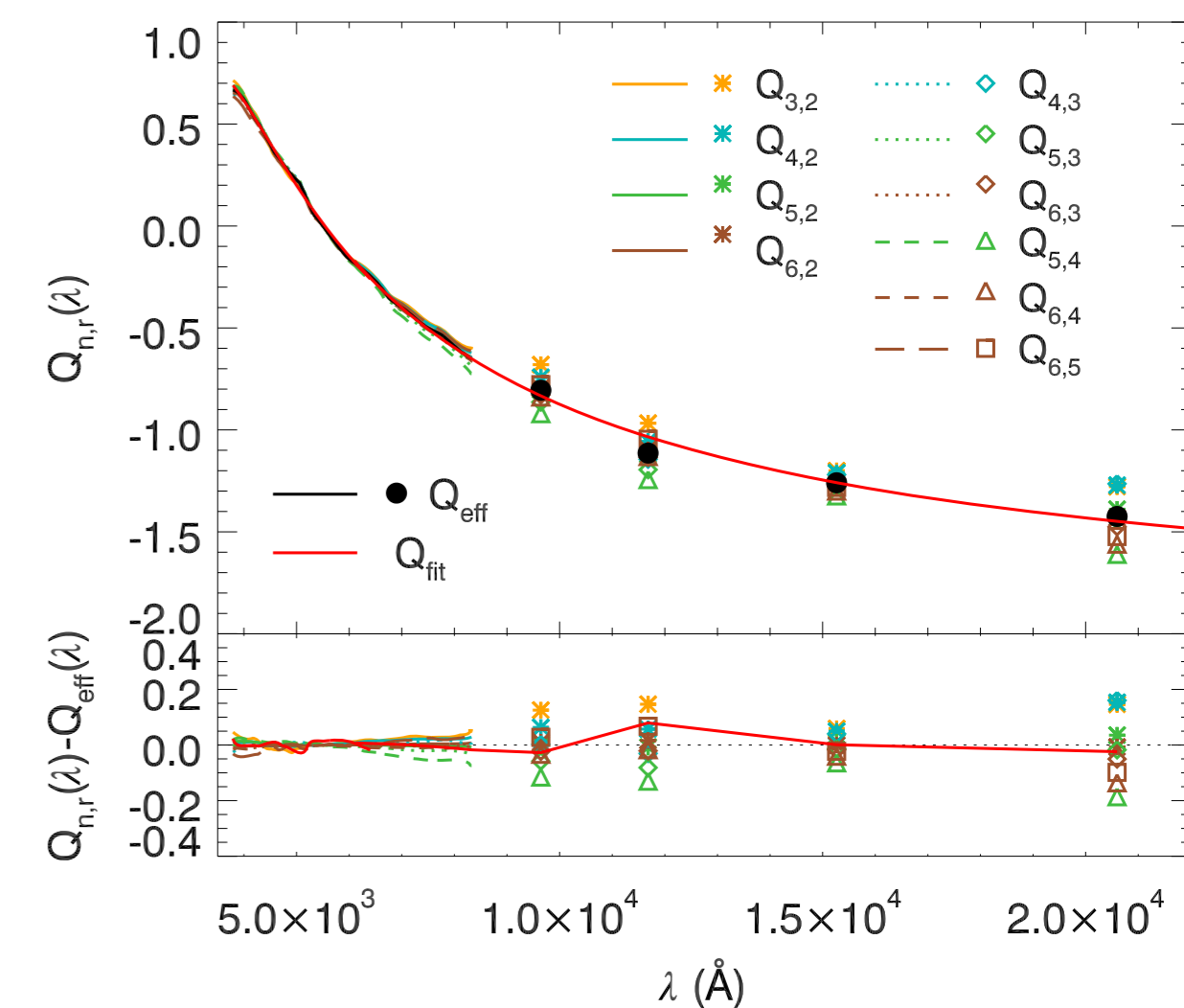
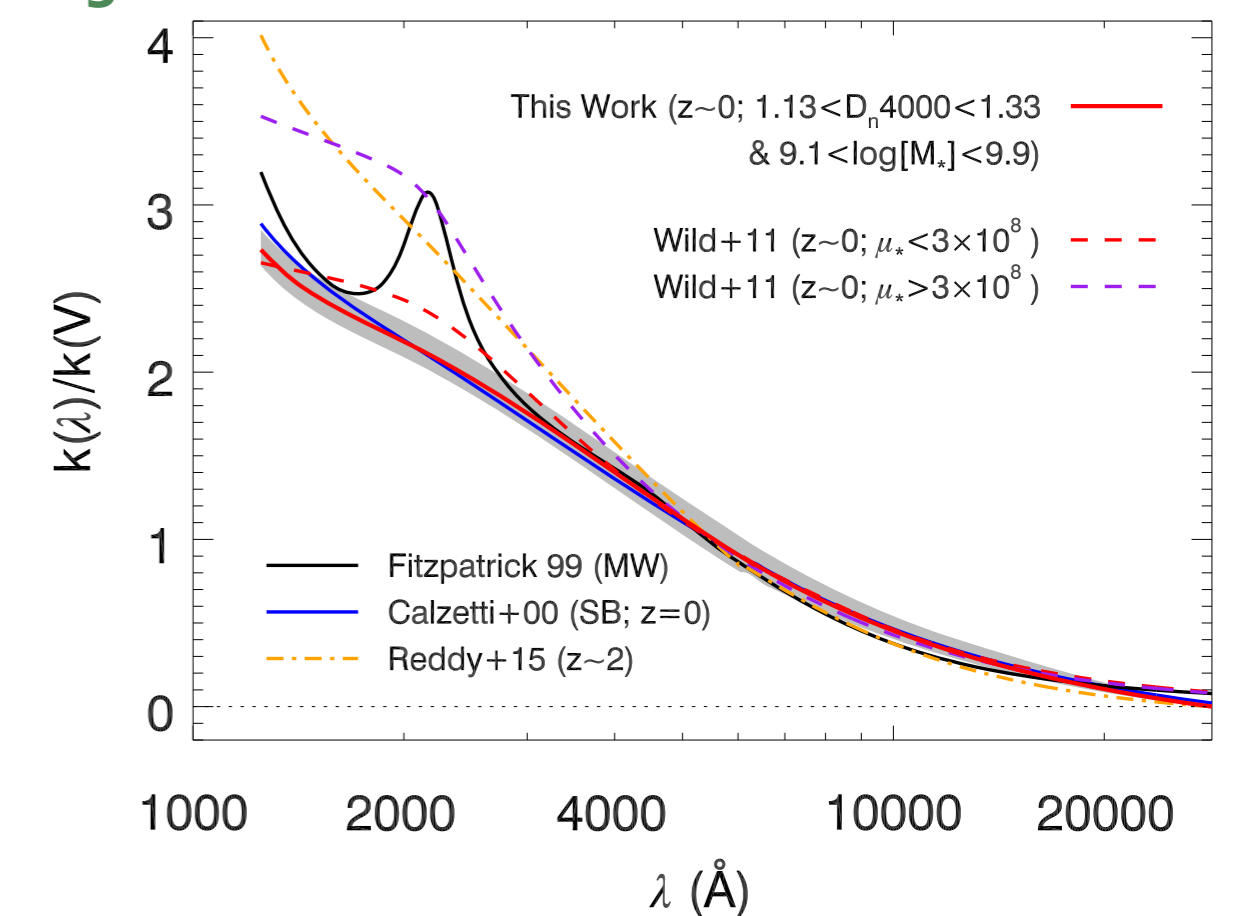


Figure 2. Average flux density of galaxies, normalized at 5500 Å

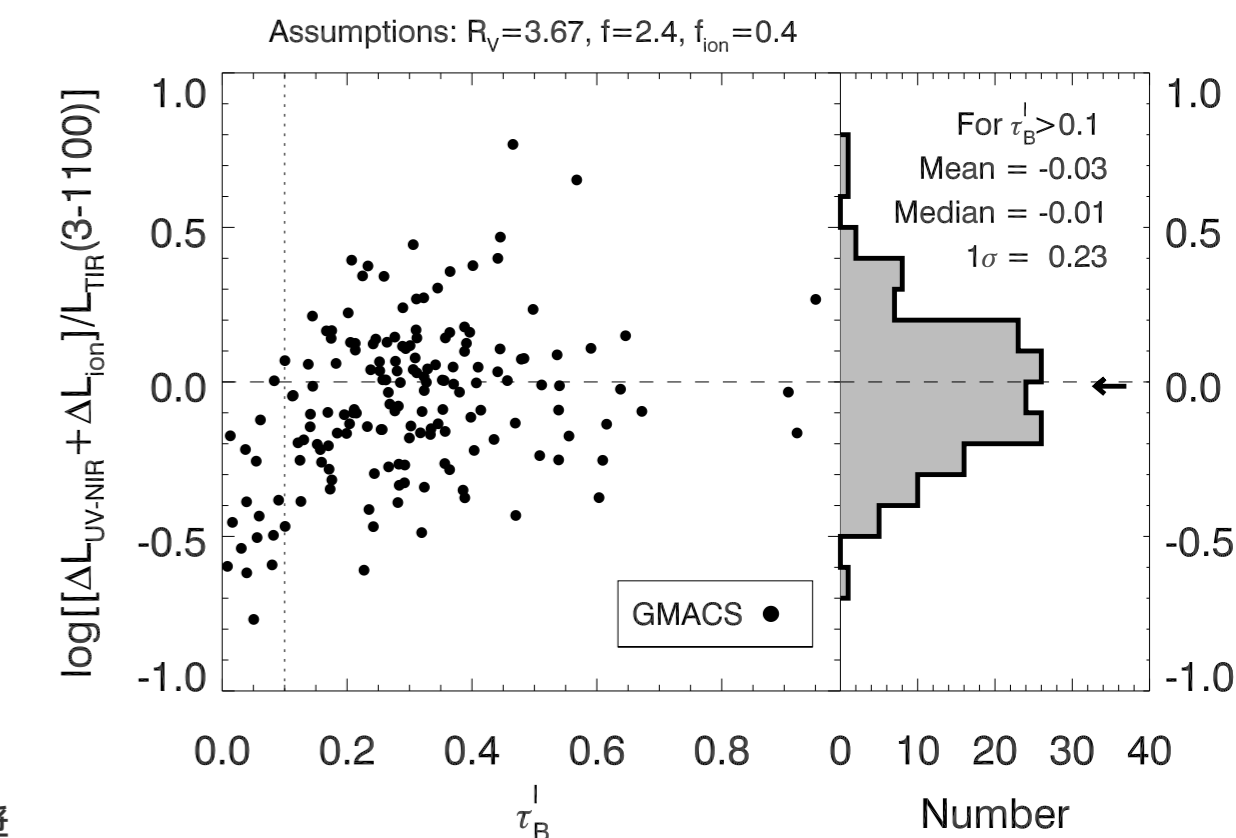
## Figure 3: テンプレートから求めた減光則



## Figure 5: V-band で規格化した減光量



## Figure 7: 減光量と赤外放射の収支の関係



## Discussion

- 減光則を近赤外線 (2μm) まで拡張
- およそ  $R_V \sim 3.67$  が成り立つ
- Calzetti+(2000) とだいたい consistent  $\Rightarrow$  UV で若干低めに見える?
- 星質量, sSFR, 年齢, 金属量との相関なし
- 減光量と赤外放射の関係  $\Rightarrow$  大きな矛盾はない  $\Rightarrow$  ただし比の分散が大きすぎる?
- UV  $\beta$  への依存性が大きい  $\Rightarrow$  星形成領域ローカルな減光の寄与  $\Rightarrow$  ダストの geometry に関わる?
- 減光則はおおむね universal  $\Rightarrow$  個々の銀河に対して使うのは非推奨