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Implications of Including AGB Dust in SPS Models

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Abstract. The IR emission from galaxies is a unique window into multiple aspects of galaxy evolution including star-formation rates, the age of galaxies, and galactic-scale dust processes. However, asymptotic giant branch (AGB) stars continue to introduce uncertainty into stellar population synthesis (SPS) models and limit our ability to interpret the IR light of galaxies. Here we focus on incorporating circumstellar dust around AGB stars in SPS models and understanding the extent to which they influence the IR light of galaxies. We find that the significance of the AGB dust contribution depends on the characteristics of the galaxy. For quiescent galaxies and metal-poor star forming galaxies, circumstellar dust emission can have a large effect, whereas for dusty star-forming galaxies the circumstellar emission is dwarfed by emission from dust in the ISM. The models with circumstellar dust also suggest, in agreement with previous work, that IR colors can be a powerful age diagnostic for older stellar systems. Models such as these will be essential for interpreting data that will be provided by JWST and other next generation IR facilities. .

Keywords. stars: AGB and post-AGB – infrared: galaxies — galaxies: stellar content

1. Overview

Stellar populations synthesis (SPS) models are one of our most powerful tools in understanding the nature of galaxies. Such models allow us to infer the physics of galaxies (e.g. the physical structure, star-formation history, and initial mass function) from observables by summing the spectra of the components of galaxies. However, we cannot expect correct answers if we do not provide correct input and so our certainty in SPS models is limited by our certainty in stellar, dust, and gas physics. Here we focus on the uncertain asymptotic giant branch (AGB) phase that low to intermediate mass ($\sim$0.1-8$M_\odot$) stars undergo after helium burning starts.

Dust rich material is observed to be around AGB stars which means that these stars are potentially important in the infrared (IR). The implications of this could be far reaching. For example, it is common practice to derive star-formation rates of galaxies based on 24μm detections, a technique predicated upon the idea that the dominate source of IR light in a galaxy is from the dusty environments of young stars which might not necessarily be true. There has been debate about when, under what circumstances, and to what extent AGB stars contribute to the mid-IR flux of galaxies. In this work, we attempt to resolve some of this uncertainty.

We made two grids of models – one for Carbon-rich stars and one for Oxygen-rich stars – with the 1D radiative transfer code DUSTY (Ivezic & Elitzur 1997) that vary as a function of effective temperature and optical depth of the dust shell. The dust shell models are connected to the SPS models using empirical relations between stellar parameters and properties of the dust shell established by Vassilliadis & Wood (1993) and Habing *et al.* (1994).

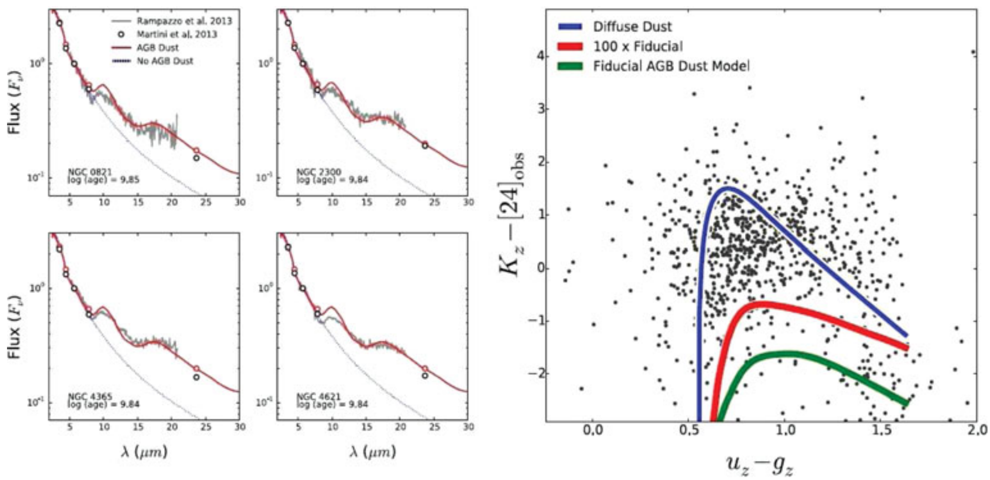

Figure 1. (a) *Spitzer* IRAC and MIPS photometry (Martini *et al.* 2013) and IRS spectroscopy (Rampazzo *et al.* 2013) of a sample of early-type galaxies compared to Z=Z$_\odot$ models with (red) and without (blue-dashed) AGB dust. (b) Color-color plot of galaxies at $z \sim 1$ from Wuyts *et al.* (2008). The data are compared to stellar population models with only diffuse dust (solid blue), a model with the default amount of AGB dust (dashed green), and a model with the AGB dust optical depth increased by a factor of 100 (red dotted).

2. Implications

In Figure 1 we compare SPS models with observations of early-type galaxies (left panel) and star-forming galaxies (right panel). In the left panel, all data were normalized to 5.72 μm and the ages were determined through by-eye fits. This figure shows that including AGB dust in the SPS models helps solve the under-prediction of the observed mid-IR flux of these galaxies by SPS models that do not include AGB dust. Our models that include AGB dust capture both the mid-IR flux and the spectral features seen at wavelengths > 8μm. This indicates that in early-type galaxies AGB stars can be considered a prominent, possibly dominant, source of the mid-IR light.

However, the same cannot be said for the star-forming galaxies shown in the right panel of Figure 1. This figure shows the mid-IR colors of galaxies at $z \sim 1$ selected from the Wuyts *et al.* (2008) sample. We show that AGB dust cannot account for the full range of mid-IR colors observed in these galaxies while diffuse dust (dust from young stars and the ISM) can. Our results indicate that the presence of diffuse dust in a galaxy overwhelms the effect of AGB dust. This result is consistent with studies of resolved populations in Magellanic Clouds (Melbourne & Boyer 2013).

References

Habing, H. J., Tignon, J., & Tielens, A. G. G. M. 1994, *AAP*, 713, L28-L32

Ivezic, Z. & Elitzur, M. 1997, *MNRAS*, 287, 799-811

Martini, P., D, Dicken, & Storci-Bergmann, T. 2013, *ApJ*, 766, 121

Melbourne, J. & Boyer, M. L., 2013, *ApJ*, 764, 30

Rampazzo, R., Panuzzo, P., Vega, O., Marino, A., Bressan, A., & Clemens, M. S. 2013, *MNRAS*, 432, 374-403

Wuyts, S., Labbé, I., Schreiber, N. M. F., Franx, M., Rudnick, G., Brammer, G. B., & van Dokkum, P. G. 2008, *ApJ*, 689, 653

Vassiliadis, E. & Wood, P. R. 1994, *ApJ*, 413, 641-657