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TP-AGB STARS AND THE MASS OF GALAXIES

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RESUMEN

Las estrellas de la TP-AGB dominan la luminosidad en la banda-K en poblaciones estelares simples de edad ≈ 1 Gyr. Las estimaciones de masa de galaxias con población estelar dominante cercanas a esta edad dependen críticamente en el tratamiento dado a estas estrellas en los modelos de síntesis de poblaciones. Presento algunos resultados preliminares de Charlot & Bruzual (in prep.).

ABSTRACT

TP-AGB stars dominate the K-band luminosity in simple stellar populations of age ≈ 1 Gyr. Mass estimates of galaxies with dominant stellar populations in this age range thus depend critically on the treatment of TP-AGB stars in population synthesis models. Here I present some preliminary results from Charlot & Bruzual (in prep.).

Key Words: galaxies: evolution — galaxies: stellar content — stars: AGB and post-AGB

1. INTRODUCTION

The estimates of the age and mass of the stellar population present in a galaxy depend critically on the ingredients of the stellar population model used to fit the galaxy spectrum. In particular, the treatment of the thermally pulsing asymptotic giant branch (TP-AGB) phase of stellar evolution is the major source of uncertainty in the determination of the spectroscopic age and mass of high-z ($1.4 < z < 2.7$) galaxies. The mid-UV spectra of these galaxies indicate ages in the range from 0.2–2 Gyr, at which the contribution of TP-AGB stars in the rest-frame near-IR sampled by Spitzer is expected to be at maximum. TP-AGB stars dominate the K-band luminosity in simple stellar populations of age ≈ 1 Gyr. Mass estimates of galaxies with dominant stellar populations in this age range thus depend critically on the treatment of TP-AGB stars in population synthesis models (Bruzual 2007).

2. TP-AGB STARS

The Charlot & Bruzual (in preparation, hereafter CB09) models are formally identical to the Bruzual & Charlot (2003; hereafter BC03) models, but include several important improvements. CB09 use the tracks up to 15 $M_\odot$ from the models with updated input physics by Bertelli et al. (2008). For stars more massive than 15 $M_\odot$, in the range from 20 to 120 $M_\odot$, CB09 use the so-called Padova 1994 tracks. In the CB09 models the TP-AGB evolution of low- and intermediate-mass stars is followed according to the prescription of Marigo & Girardi (2007). This semi-empirical prescription includes several important theoretical improvements over previous calculations, and it has been calibrated using carbon star luminosity functions in the Magellanic Clouds and TP-AGB lifetimes (star counts) in Magellanic Cloud clusters. While the tracks used

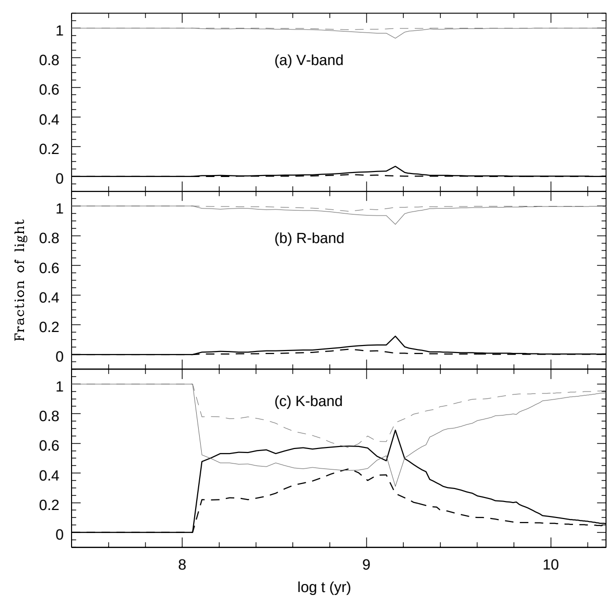

Fig. 1. Panels (a), (b), and (c): Fraction of light contributed by TP-AGB stars (black lines) and the "rest" of the stars (gray lines) as a function of time in the V, R, and K-bands, respectively, for the CB09 SSP model (solid lines) and the BC03 SSP model (dashed lines), both for $Z = Z_\odot$.

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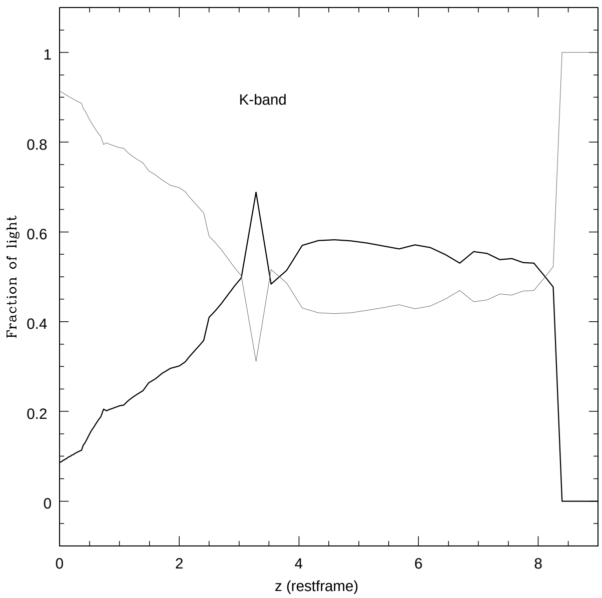

Fig. 2. Fraction of light contributed by TP-AGB stars (black line) and the "rest" of the stars (gray line) in the K-band as a function of redshift in the restframe of the galaxy for the CB09 $Z = Z_{\odot}$ SSP model.

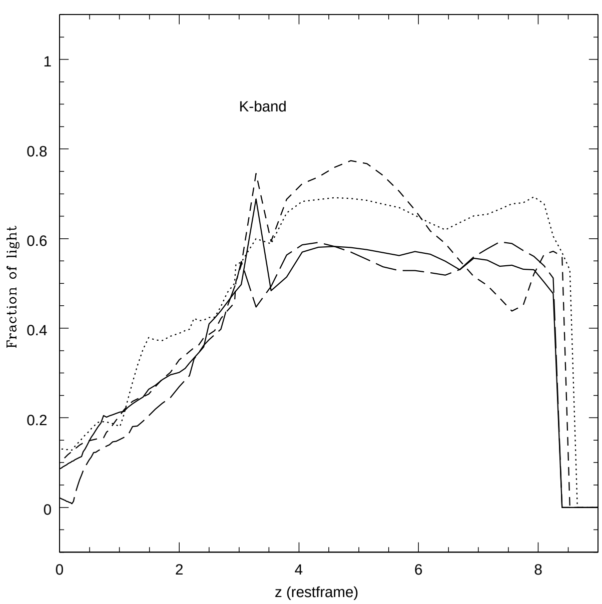

Fig. 3. Fraction of light contributed by TP-AGB stars in the K-band as a function of redshift in the restframe of the galaxy for the CB09 SSP models of the following metallicities: $Z = 0.25 \times Z_{\odot}$ (dotted line), $Z = 0.5 \times Z_{\odot}$ (short dashed line), $Z = Z_{\odot}$ (solid line), and $Z = 2.5 \times Z_{\odot}$ (long dashed line).

in CB09 account for 15 evolutionary stages in the TP-AGB (six in the O-rich phase, six in the C-rich phase, and three in the superwind phase), the BC03 models include only 1 evolutionary stage at each of these phases. The resulting CB09 isochrones are thus based on internally consistent sets of tracks, which naturally obey the fuel consumption theorem, and provide other quantities necessary for a consistent modelling of galaxies, such as chemical yields and remnant masses (Marigo et al. 2008). Figure 1 shows the fraction of light contributed by TP-AGB stars and the "rest" (i.e. everything else) of the stars as a function of time and as a function of redshift in the galaxy rest frame for various models. Whereas in the V and R-bands in the $Z = Z_{\odot}$ model the TP-AGB stars never contribute more than a few percent, in the K-band this contribution reaches close to 60–70% in the CB09 model. The TP-AGB stars in the CB09 models contribute close to a factor of two more light in the K-band than in the BC03 model, which use a different prescription for the TP-AGB evolution. At maximum, the TP-AGB contributes close to 70% of the K-light in the CB09 model but only 40% in the BC03 model. The peak emission in the BC03 model occurs at around 1 Gyr whereas in the CB09 model it stays high and close to constant from 0.1 to 1 Gyr. Plotting the fraction of light vs. redshift (Figure 2) it becomes clear why the physics of TP-AGB stars dominates so strongly the determination of the total mass contained in the stellar populations of galaxies. When examining the light emitted in the restframe by galaxies in the redshift range from $z = 3$ to $z = 8$, close to 60% of the light in the K-band comes from the TP-AGB stars. The mass that we assign to these galaxies is inversely proportional to the galaxy luminosity. The brighter the model galaxy, the lower the mass in stars needed to produce a given galaxy luminosity. For all metallicities (Figure 3) the contribution of TP-AGB stars in the K-band is above 60%. Thus, uncertainties in the physical properties that we assign to these stars have a direct influence in the mass that we attribute to galaxies in this redshift range.

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