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POSSIBLE SOURCES OF UV RADIATION IN ELLIPTICAL GALAXIES

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RESUMEN

Hemos compilado una muestra de 519 galaxias elípticas cercanas ($z < 0.13$), seleccionadas mediante una correlación entre el sondeo Medium Imaging Survey (MIS) realizado por el Galaxy Evolution Explorer (GALEX) y el Sloan Digital Sky Survey (SDSS) Fourth Data Release (DR4). Las galaxias de nuestra muestra son relativamente brillantes, $r < 16.8$, y tienen emisión en el FUV (ultravioleta lejano) y en el NUV (ultravioleta cercano). Definimos nuestra muestra de galaxias de tipo temprano usando un criterio morfológico. Construimos una Relación Color Magnitud UV (CMR) usando las bandas fotométricas del GALEX y el SDSS, y analizamos la evolución del CMR para estas galaxias usando los modelos de síntesis de poblaciones estelares (Bruzual & Charlot 2003). Encontramos que estas galaxias pueden haber sufrido un pequeño brote de formación estelar residual, de masa aproximada al 1–2% de la masa de la galaxia. Sin embargo, para galaxias con $4 < \mathrm{NUV} - r < 5.4$, este exceso UV puede ser debido a estrellas evolucionadas de la rama horizontal extrema (EHB).

ABSTRACT

We have compiled a sample of 519 nearby ($z < 0.13$) elliptical galaxies, selected by matching the Galaxy Evolution Explorer (GALEX) Medium Imaging Survey (MIS) with the Sloan Digital Sky Survey (SDSS) Fourth Data Release (DR4). Our galaxies are bright, with $r < 16.8$ and have FUV (far ultraviolet) an NUV (near ultraviolet) emission. We build a UV Color Magnitude Relation (CMR) using GALEX and SDSS photometric bands, and analyze the evolution of this CMR for these galaxies using stellar population synthesis models. We find that these galaxies may have suffered a small amount of recent residual star formation (1–2% of the galaxy mass). Extreme Horizontal Branch (EHB) stars can explain galaxies with $4 < \mathrm{NUV} - r < 5.4$.

Key Words: galaxies: elliptical and lenticular, cD — stars: formation — stars: horizontal-branch

1. INTRODUCTION

Either massive enough young stars or evolved low mass stars can be responsible for the UV emission in elliptical galaxies. A recent burst of star formation in an elliptical galaxy can be detected by its effects on the UV-optical color magnitude diagram (CMD) of a sample of galaxies. The near UV (NUV) light is more sensitive to the presence of young stars than the U band, and the young population will produce scatter on this diagram. (Schawinsky et al. 2006; Kaviraj et al. 2006). Evolved low mass stars may be responsible as well of the UV emission (Gil de Paz et al. 2005). The main goal of this work is to use stellar population synthesis models to distinguish between these two possible sources of UV radiation in early type galaxies.

2. THE SAMPLE

We select a sample of elliptical galaxies from the SDSS DR4, using morphological criteria and photometric parameters (Schawinsky et al. 2006; Kaviraj et al. 2006), and then cross-match it with the GALEX MIS DR2 sample to obtain a set of galaxies with both UV and optical data. We choose galaxies with concentration index $r_{90}/r_{50} > 2.5$. Our galaxies have limiting apparent magnitude $r < 16.8$, to guarantee completeness to $\mathrm{NUV} - r = 6.2$, which corresponds to the top of the red sequence (Yi et al. 2005). All galaxies have $z < 0.13$. The final sample contains 519 elliptical galaxies.

3. STELLAR POPULATION SYNTHESIS ANALYSIS

The NUV band is very sensitive to the presence of a hot stellar population. The scatter of ~ 5 mag observed in the NUV-r color is considered clear evidence of the presence of these stars in early-type galaxies. In the NUV-optical CMD (Figure 1) a significant number of galaxies are bluer than $\mathrm{NUV} - r = 5.4$. Galaxies below this limit are too blue to be consistent with the monolithic scenario of galaxy formation (Kaviraj et al. 2006).

3.1. *Stellar Populations with Two Starbursts*

An elliptical galaxy can have a residual star formation (Kaviraj et al. 2006; Bruzual & Charlot

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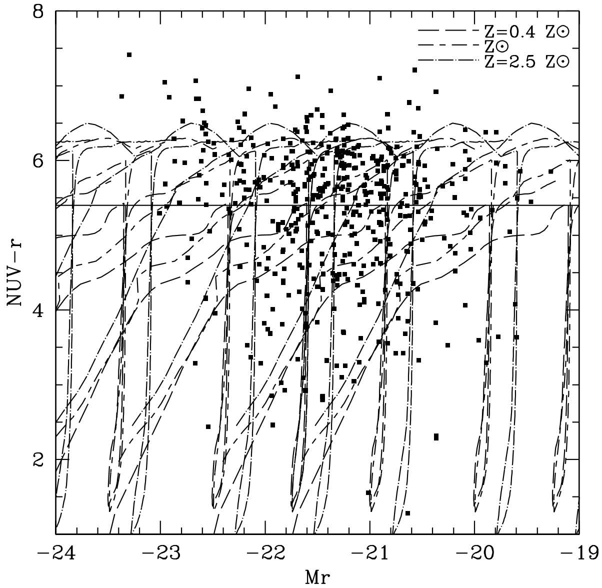

Fig. 1. Each line represent the NUV-r color evolution for models with residual star formation for 0.4, 1, and 2.5 × solar metallicity. The line NUV $- r = 5.4$ is the lower limit for the red sequence. Note that all models cover the range of observed colors in our sample (black dots).

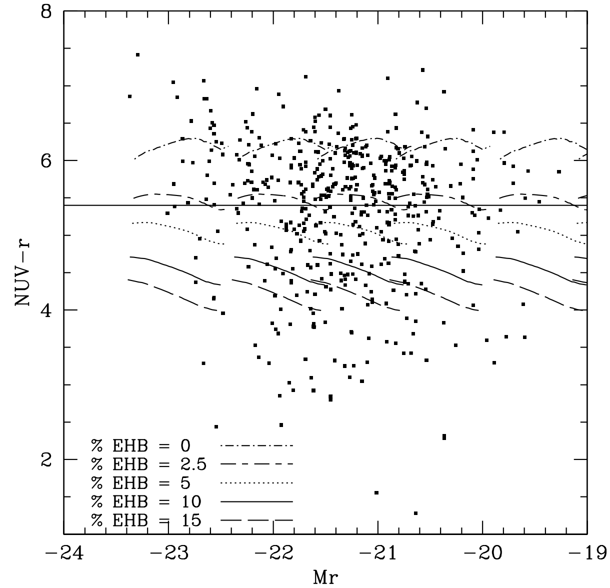

Fig. 2. Models for 0, 2.5, 5, 10, 15% of EHB stars and different galaxy mass (1×10^8 to 5×10^{11} $M_\odot$, left to right). All models are for solar metallicity.

2003). We can reproduce this scenario if we include a second burst of star formation in a simple stellar population model. We calculate models with different metallicities (0.4, 1 and 2.5 × solar metallicity) and follow the time evolution from $t = 0.3$ to $t = 14$ Gyr (Figure 1). The amount of mass formed into stars in the second burst is $\leq 2\%$. When the second burst occurs, the NUV-r color becomes bluer for a short period of time (~ 0.3 Gyr), due to the presence of young stars. Later on, the recently formed stars evolve and the model turns red again.

3.2. *Stellar Populations with EHB stars*

We consider next the inclusion of EHB stars in our simple stellar population model. These stars are not present in the tracks used in the BC03 models. We calculate four models in which 2.5, 5, 10 and 15% of the low mass stars in the red giant branch evolve to the EHB. Figure 2 shows the resulting color evolution. Note that these models can reproduce NUV-r values ≥ 4. Thus, the NUV-r color of galaxies below the red sequence but redder than ~ 4 can be understood by either recent star formation or the presence of EHB stars. Galaxies with NUV-r color bluer than ~ 4 require recent star formation.

4. CONCLUSIONS

We analyze two scenarios to produce early-type galaxies with NUV-r color bluer than 5.4. A second burst of star formation of $\leq 2\%$ amplitude in mass is enough to explain all galaxies below NUV $- r = 5.4$. EHB stars can explain galaxies with $4 <$ NUV $- r <$ 5.4. Galaxies bluer than NUV $- r = 4$ necessarily require a recent star formation episode.

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