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A MULTIWAVELENGTH STUDY OF STARBURST GALAXIES

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RESUMEN

Se investiga la historia de la formación estelar en una muestra de 19 galaxias starburst usando fotometría J, H y K de banda ancha y espectroscopía UV, óptica y de IR cercano. Se obtiene un *espectro starburst patrón* combinando todos los datos, luego de corregir por enrojecimiento, y se compara con modelos de síntesis de poblaciones estelares. Se requieren al menos tres poblaciones estelares con edades de $\sim$1–2$\times 10^9$ años, para ajustar las observaciones. La población estelar responsable de la emisión UV observada tiene una tasa de formación estelar (SFR) constante y una edad de alrededor de 2$\times 10^7$ años. Se utiliza una funcíon inicial de masas de tipo Salpeter, con masas de 0.1 a 100 $M_{\odot}$ que, se demuestra, está en buen acuerdo con las observaciones.

ABSTRACT

J, H, and K broad band photometry and UV, optical, and near-IR spectroscopy are used to investigate the star formation history of a sample of 19 starburst galaxies. By combining the reddening-corrected data, a *template starburst spectrum* is obtained and compared with synthetic spectra of stellar population models. At least three different stellar populations, spread over an age range of $\sim$1–2$\times 10^9$ yr, are required to fit the observations. The stellar population responsible for producing the observed UV emission is characterized by constant star formation rate (SFR) and an age around 2$\times 10^7$ yr. A Salpeter Initial Mass Function (IMF) with mass range 0.1–100 $M_{\odot}$ has been used in the models, and is shown to be in agreement with the observational constraints.

Key words: **GALAXIES: STARBURST — GALAXIES: STELLAR CONTENT — STARS: FORMATION**

1. INTRODUCTION

The investigation of the star formation history in starburst galaxies helps to gain insight into the starburst phenomenon. The influence of the burst of star formation on the surrounding environment (e.g., Heckman et al. 1990) and the feedback from the host galaxy determine the evolution and the duration of the event, which is reflected onto the stellar populations generated during the starburst episode(s). Characteristics of the galaxy environment may in principle affect the IMF of the new generations of stars, although there is increasing evidence that this may not be the case at the high end of the IMF (cf., Massey et al. 1995; Moffat 1996; Leitherer & Stasinska 1996). The present study is aimed at deriving the properties of the stellar populations in a "typical" starburst galaxy, by using spatially-integrated multiwavelength spectro-photometric information of a small sample of galaxies.

2. THE SAMPLE AND THE DATA

The sample of 19 galaxies includes, among others, well-known objects such as NGC 1614, NGC 4194, NGC 6090, NGC 7714, characterized by central bursting regions. The UV spectra are from the *IUE* archive (Kinney et al. 1993), and the optical and near-IR spectra have been obtained in *IUE*-matched apertures (McQuade et al. 1995; Storchi-Bergmann et al. 1995; Calzetti et al. 1996). The J, H, and K broad band photometric data also were extracted to match the *IUE* aperture (Calzetti 1996), so consistent information is available at all wavelengths. The UV and optical spectra cover continuously the wavelength range 0.125–1.0 μ, while the near-IR spectra are centered at the wavelengths of Paβ(1.282 μm) and Brγ(2.166 μm). At the typical galaxy distance of $\sim$60 Mpc the area subtended by the *IUE* aperture has physical size of about 4 kpc, and includes entirely the galaxy bursting region.

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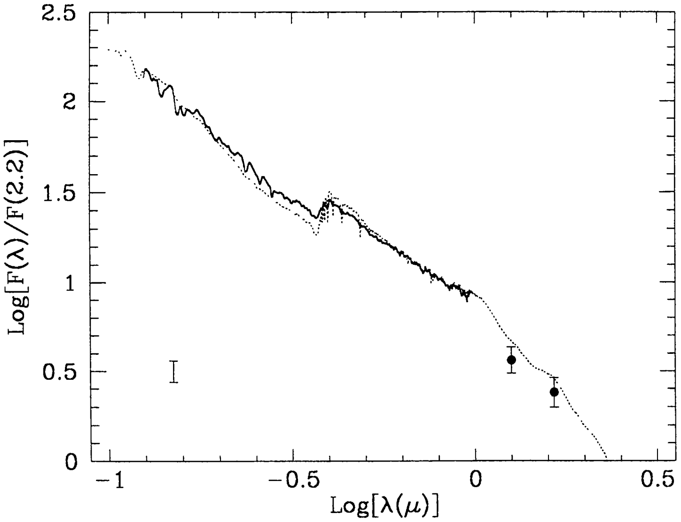

Fig. 1. The template starburst spectrum is compared with the best fitting synthetic spectrum. The templat is normalized to the K-band flux, and covers continuously the wavelength range 0.125–1.0 μm (solid line); th two filled circles are the mean J and H broad band data. The error bar at the bottom left corner shows th typical 1 σ uncertainty of the template. The synthetic spectrum (dotted line) is obtained by combining thre stellar populations: a constant SFR population 2×10^7 yr old, and two underlying populations originated b instantaneous bursts of star formation 1×10^8 yr and 5×10^8 yr ago, respectively.

TABLE 1

COMPARISON BETWEEN OBSERVATIONS AND MODELS

	Equivalent Widths		
	$H\alpha$ (Å)	$Pa\beta$ (Å)	$Br\gamma$ (Å)
Template Spectrum	100.	18.	14.
Model Spectrum	129.	21.	14.

The dust reddening corrections of the data were performed following the recipes given in Calzetti et a (1994, 1996) and Calzetti (1996). Here the obscuration affecting the starburst is modeled by a clumpy foregroun dust distribution, and two different values of the optical depth are applied to the nebular emission lines an to the stellar continuum. After reddening-correction, the data were averaged to produce a mean spectrum, th Template Starburst Spectrum (TSS), which covers the wavelength range 0.125–2.2 μm (see Figure 1).

3. COMPARISON WITH MODELS

Spectral synthesis models (Bruzual & Charlot 1996; Leitherer & Heckman 1995) were used to derive th stellar populations which contribute to the TSS. The adopted IMF is Salpeter with mass range 0.1–100 $M_\odot$ and the metallicity of the model stellar populations is solar. The latter is not a limiting factor, since most c the galaxies in the sample have oxygen abundances in the range 0.5–1 $[O/H]_\odot$.

The fitting technique involves the minimization of the differences between models and observations for bot the stellar continuum (the TSS) and the equivalent width of the atomic hydrogen emission lines. The mea observed values for the equivalent widths are reported in Table 1.

4. RESULTS

The best fit model is shown in Figure 1, and requires at least three components, spread over a 1 Gyr ag range. The first component is a stellar population undergoing star formation at a constant rate since 2×10^7 yı and is responsible for most of the observed UV emission in the TSS. The other two populations were generate by instantaneous bursts 1×10^8 and 5×10^8 yr ago, respectively, and are responsible for a large fraction of th optical continuum emission and most of the infrared emission. The predicted values of the hydrogen emissio

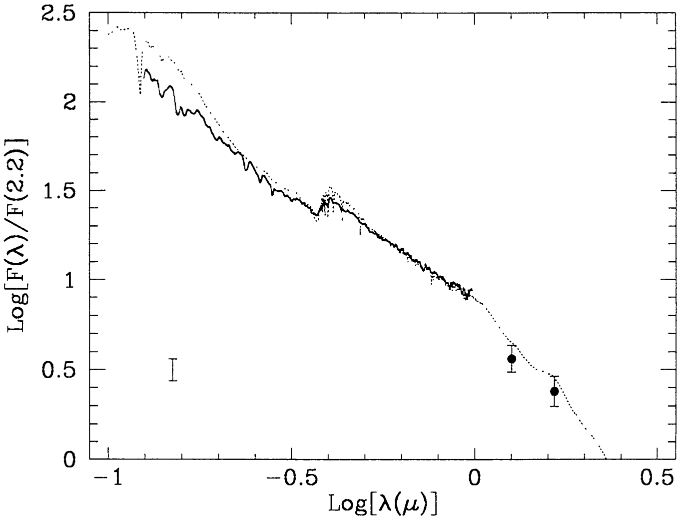

Fig. 2. The template starburst spectrum is compared with a 1 Gyr old stellar population with constant SFR. The scale and the labels are as in Figure 1.

line equivalent widths are shown in Table 1, together with the observed values. No stellar component older than 2 Gyr is required to fit the TSS, indicating that the observed spectra are dominated by the contribution of stellar populations related to the starburst event. The model is able to reproduce observational constraints other than the spectral energy distribution and the EWs of the nebular lines. For instance, the predicted K-band luminosity per unit of SFR is $L_K/SFR = 5.3\times10^9\ L_\odot\ yr/M_\odot$ to be compared with the mean observed value $L_K/SFR = 5.9\times10^9\ L_\odot\ yr/M_\odot$.

A reasonable fit of the TSS is obtained also with a stellar population undergoing star formation at a constant rate since 1–2 Gyr (see Figure 2). This suggests that the star formation in the sample galaxies may have been continuous, or episodic but diluted over a relatively long period of time. Given the size of the region subtended by our observational aperture (4 kpc on average), it is possible that the star formation event has not been limited to a single, small region, but has propagated through the central region of the galaxy during its lifetime.

Low values of the *observed* mass-to-light ratio are usually suggested as evidence for a IMF deficient in low mass stars (for the case of the starburst galaxy M82, see Rieke et al. 1993; cf., however, Satyapal et al. 1995). The mean observed value of the mass-to-light ratio is 1.4 $M_\odot/L_{K,\odot}$ for the present sample; the value from the best fit model is 0.3 $M_\odot/L_{K,\odot}$, or about 4.5 times smaller than the mean observed value. The difference between the two values allows room for the presence of low mass stars older than 2 Gyr, and for atomic and molecular gas. It also indicates that the choice of a lower limit for the IMF as small as 0.1 $M_\odot$ is not in contradiction with the observations.

REFERENCES

Bruzual, G., & Charlot, S. 1997, in preparation
Calzetti, D. 1997, in preparation
Calzetti, D., Kinney, A. L., & Storchi-Bergmann, T. 1994, ApJ, 429, 582
Calzetti, D., Kinney, A. L., & Storchi-Bergmann, T. 1996, ApJ, 458, 132
Heckman, T. M., Armus, L., & Miley, G. 1990, ApJS, 74, 833
Kinney, A. L., Bohlin, R. C., Calzetti, D., Panagia, N., & Wyse, R. F. G. 1993, ApJS, 86, 5
Leitherer, C., & Heckman, T. M. 1995, ApJS, 96, 9
Massey, P., Lang, C. C., de Gioia-Eastwood, K., & Garmany, C. D. 1995, ApJ, 438, 188
McQuade, K., Calzetti, D., & Kinney, A. L. 1995, ApJS, 97, 331
Rieke, G. H., Loken, K., Rieke, M. J., & Tamblyn, P. 1993, ApJ, 412, 99
Satyapal, S., et al. 1995, ApJ, 448, 611
Stasinska, G., & Leitherer, C. 1996, ApJS, 107, in press
Storchi-Bergmann, T., Kinney, A. L., & Challis, P. 1995, ApJS, 98, 103