



Stellar population synthesis of the galaxies NGC2336 and NGC2841

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Abstract. We examined the spectra of the galaxies NGC2336 and NGC2841 in order to determine a model of the stellar population for different regions of the galaxies. The two-dimensional spectra were divided into regions along the slit and the obtained monodimensional spectrum of each region was compared with a linear combination of stellar spectra of different types, from O to M. We also examined the influence of intrinsic reddening, considering one of the analysed spectra.

1. Introduction

The observed spectrum of a given galaxy is the combination of the flux emitted from the stars and eventually from the ionized gas. As a consequence, the total spectrum depends on the percentage different type of stars. Stellar population synthesis is a method that attempts to reproduce the observed spectrum of a galaxy with a linear combination of stellar spectra of various types. This studies are crucial in understanding the formation and evolution of galaxies.

A galaxy does not have an uniform composition of stars: the amount of young and old stars changes in its substructures. In the center of the galaxy (bulge) there are older and colder stars than in the disk and arms, where the stars are younger and hotter. Moreover, in the outer regions of spiral galaxies the amount of gas is greater than in the bulge. The interstellar gas and dust have consequences on the spectra as well, through an effect called “galactic extinction”, which occurs when the light undergoes an absorption and a scattering as a function of the wavelength. Since the size of the dust granules is similar to the blue light wavelength (400 nm), the intensity of the blue light is more attenuated than the red light, resulting in a spectrum redder than expected (reddening). This phenomenon can lead to an underestimation of the blue star component in the galaxy population.

2. Observational Data

We analysed the spectra of the two galaxies, NGC2336 and NGC2841 (images in Figs. 1 and 2), taken with the 1.22-m Galileo telescope at the Asiago Astrophysical Observatory, equipped with a B&C spectrograph, 300

Table 1. Observational parameters.

Object	exp. time (s)	P.A.(°)
NGC 2336	1800	75
NGC 2841	900	60

Table 2. Characteristics of our galaxies, data source: NED archive.

Object	NGC2336	NGC2841
R.A.	07h 27m 04.05s	09h 22m 02.634s
Dec.	+80d 10m 41.1s	+50d 58m 35.47s
Morph. Type	SAB(r)bc	SA(r)b
V mag	10.43	9.22
d (Mpc)	33.617	17.823
z (in 10^{-3})	7.35	2.128

gr/mm grating and 200 μ m slit width. The telescope scale is 10.78 arcsec/mm, while the CCD scale is 0.63 arcsec/pixel. Exposure time and slit position angle (P.A.) are reported in Table 1, whereas the main features of the galaxies are reported in Table 2.

3. Work description

Using the IRAF (Image Reduction and Analysis Facility - NOAO) package, we started extracting the monodimensional spectra from the two-dimensional spectra. We selected few regions examining the H α emission line, obtaining the intensity profile from the center to the edge of our galaxies (see Figs. 3 and 4).



Fig. 1. Digitized Sky Survey image of NGC 2336.

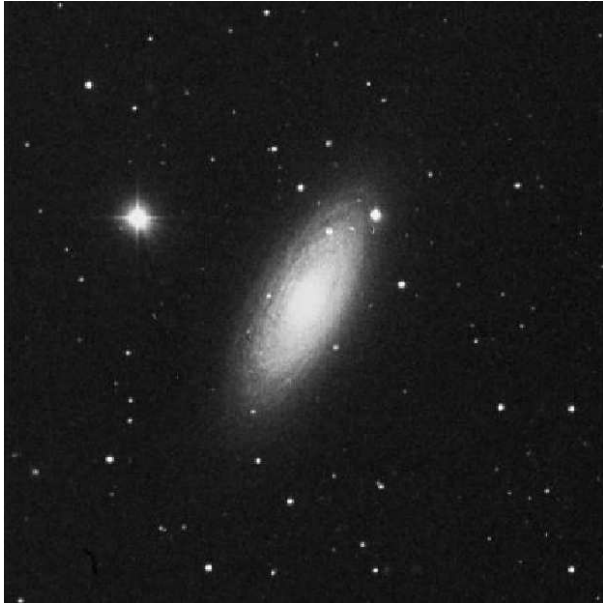


Fig. 2. Digitized Sky Survey image of NGC 2841.

We have examined 6 regions in NGC2841 and 6 in NGC2336. For each spectrum we made various corrections.

The first step was to correct the reddening of the spectrum due to the interstellar medium of our galaxy, the Milky Way, using the task DEREDDEN of the package ONEDSPEC. We used the value $A(V)$, taken from the Nasa/Ipac extragalactic database, which is 0.052 mag for NCG2841 and 0.109 mag for NGC2336. $A(V)$ is the total extinction in the visual band of 5550 Å. For



Fig. 3. Intensity profile of the $H\alpha$ line in NGC 2841. The yellow arrow indicates the peak corresponding to a field star.

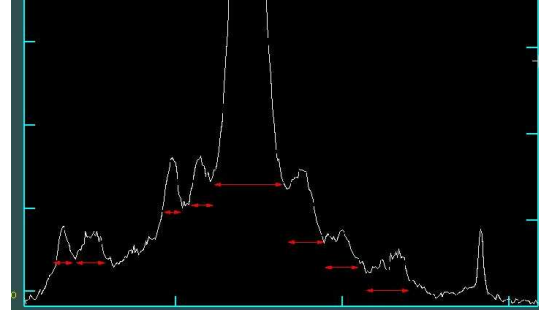


Fig. 4. Intensity profile of the $H\alpha$ line in NGC 2336. Can be noticed the presence of several regions where the $H\alpha$ emission is enhanced.

Table 3. Redshift z (in units of 10^{-3}) measurements for the selected spectral lines.

lines	NGC2336	NGC2841
$H\beta$	–	2.50
[NII]	7.22	1.97
Na	7.42	–
CaK	7.45	–
CaH	7.22	–
$\bar{z}$	7.33	2.23

one region of NGC2336, we also applied the reddening correction due to intrinsic extinction. We assumed three different values for $A(V)$: 0.25 - 0.75 - 1.50.

The next step was to correct the redshift (z), procedure done with the task NEWREDSHIFT of the package TOOLS. The redshift was measured on the central region, to avoid the galaxy rotation effect. We calculated the redshift using the following equation:

$$z = \frac{v}{c} = \frac{\Delta\lambda}{\lambda_0}$$

In Table 3 are shown the redshift measurements for different spectral lines (in units of 10^{-3}). Our measurements are in good agreement with those found in the Nasa/Ipac extragalactic database.

Table 4. Best stellar population for the different regions of NGC2841.

region	stellar population
<i>a</i>	55% G 40% K 5% M
<i>b</i>	50% G 45% K 5% M
<i>c</i>	30% G 70% K
<i>d</i>	55% G 45% K
<i>e</i>	60% G 40% K
<i>f</i>	80% F 15% G 5% K

Table 5. Best stellar population for the different regions of NGC2336.

region	stellar population
<i>a</i>	10% B 60% F 30% G
<i>b</i>	70% F 10% G 20% K
<i>c</i>	80% F 15% G 5% K
<i>d</i>	15% F 25% G 55% K 5% M
<i>e</i>	20% G 80% K
<i>f</i>	20% F 10% G 60% K 10% M

Table 6. Effects of changing the intrinsic extinction on the stellar population, case of NGC2336 (*a*).

A(V)	stellar population
0.11	10% B 60% F 30% M
0.25	25% B 50% F 25% G
0.75	40% B 30% F 30% G
1.50	80% B 10% F 10% G

In order to compare library stellar spectra with the our observed ones, we normalized them, so that at 5500Å the intensity value was 1 (arbitrary units). We have smoothed each spectrum (key *s* of SPLOT; pixel number: 5.) to reduce the noise.

The last step was to convert the spectra from FITS format to ASCII tables (task WSPECTEXT), in order to use the software TOPCAT to continue the analysis.

3.1. Analysis

Library spectra of different stellar types (from O to M), were used to obtain the model spectra of our galaxies. We considered a mean spectrum for any different spectral type (O, B, A, F, G, K, M), taking the mean value of the various subclasses (e.g.: B1, B2, B3....B9).

Using TOPCAT, we tried many different linear combinations of the standard stellar spectra in order to fit our galaxies spectra as good as possible. The best models we obtained for each galaxy region are described in Tables 4 and 5. In Table 6 we show the effects of different assumptions for A(V), the intrinsic extinction, on the stellar population of the galaxy.

In Figs. 5 and 6 we show some examples of the obtained fit.

Table 7. Residuals computed for galaxy NGC2841.

region	mean	σ	min	max
<i>a</i>	0.0235	0.1144	-0.2579	1.4896
<i>b</i>	0.0292	0.0976	-0.2165	1.0238
<i>c</i>	0.0044	0.0639	-0.2350	0.2018
<i>d</i>	0.0436	0.1080	-0.4373	1.2786
<i>e</i>	0.0496	0.1474	-0.6732	1.8546
<i>f</i>	0.0718	0.4706	-2.1342	6.6196

Table 8. Residuals computed for galaxy NGC2336.

region	mean	σ	min	max
<i>a</i>	0.0520	0.2206	-0.6962	2.3296
<i>b</i>	0.2542	0.1761	-0.5991	1.3066
<i>c</i>	0.0411	0.1975	-0.5005	2.0669
<i>d</i>	0.0446	0.1167	-0.5596	0.7848
<i>e</i>	0.0175	0.0679	-0.2593	0.2351
<i>f</i>	0.0499	0.1931	-1.2014	0.9319

We also analyzed the residual (O-C) that is the difference between the observed galaxy spectrum and the synthetic one (the model). We computed the mean value, the standard deviation σ and the minimum and maximum values of the model, in order to evaluate the obtained fit (see Tables 7 and 8). As can be seen, besides the region “*f*” of NGC2841 and region “*a*” of NGC2336, these values support the reliability of our fit, although the fitting was made “by eye”.

4. Results

As expected, the galaxies show a different stellar distribution from the center to the edge. The bulge has more stars of the late spectral types, while on the edge we found hot and young stars. In fact, the disk and the spiral arms are the areas where the star formation is more active. For galaxy NGC2336 the fit was more difficult and, in the end, the results were less satisfactory than the ones for galaxy NGC2841. We found a quite good symmetry in our models with respect to the galactic center. Only for region *a* of galaxy NGC2336 we tried to consider three different values of the intrinsic extinction. We showed that this parameter has a great influence on the stellar composition models: in fact, the hot and cold star percentages vary from 25% vs. 25% to 80% vs. 10% when A(V) changes from 0.25 to 1.5. Unfortunately, the intrinsic reddening for a given galaxy is not known and rigorous models consider A(V) as a free parameter to be fitted by the model itself. NGC2336 shows a few percentage of M star, compared with NGC2841 that seems dominated by G, K and M stars.

References

<http://nedwww.ipac.nasa.gov>

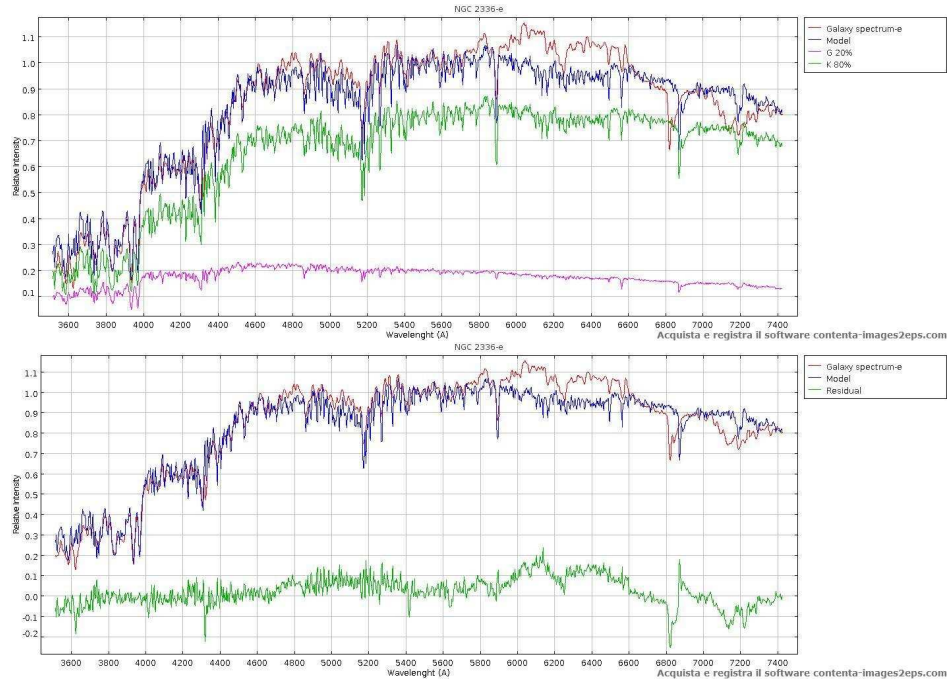


Fig. 5. Top: fit for NGC2336 *e* region. Observed and theoretical spectra are indicated with the red and the blue line respectively. The green line shows the contribution of K stars (80%), whereas the magenta line that of G stars (20%). Bottom: the spectrum of the same region. Here the green line shows the residuals.

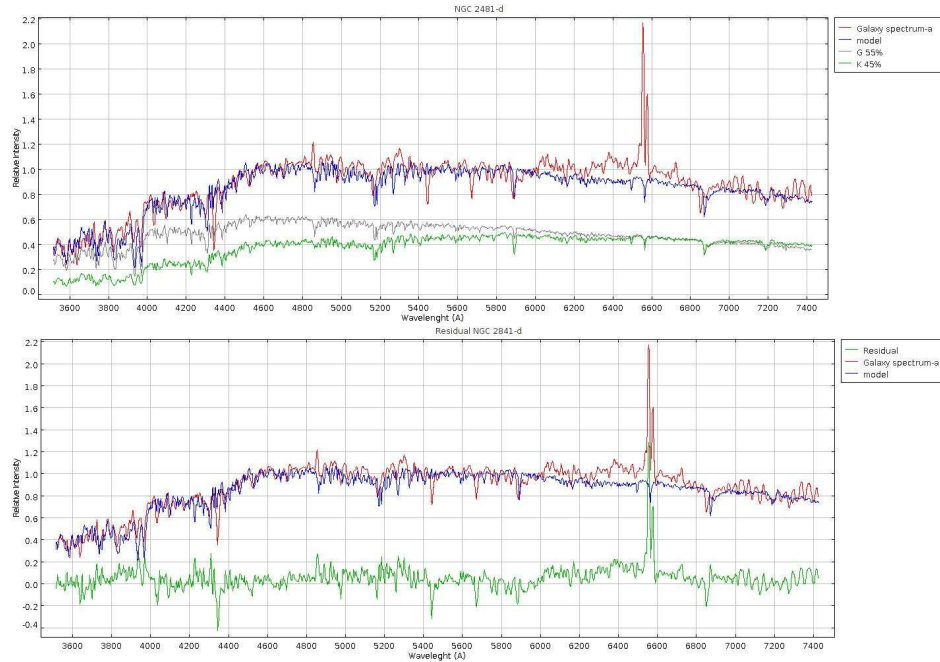


Fig. 6. Top: fit for NGC2841 *d* region. Observed and theoretical spectra are indicated with the red and the blue line respectively. The green line shows the contribution of K stars (45%) whereas the gray line that of G stars (55%). Bottom: the spectrum of the same region. Here the green line shows the residuals.