Modelling the spectro-photometric and chemical evolution of Low Surface Brightness spiral galaxies

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Abstract

We investigate the star formation history and chemical evolution of Low Surface Brightness (LSB) spiral galaxies by means of their observed spectro-photometric and chemical properties. We present preliminary results for Johnson-Cousins UBVRI magnitudes and stellar [O/H] abundance ratios using a galactic chemical evolution model incorporating a detailed metallicity dependent set of stellar input data covering all relevant stages of stellar evolution. Comparison of our model results with observations confirms the idea that LSB galaxies are relatively unevolved systems. However, we argue that recent and ongoing massive star formation plays an important role in determining the colours of many LSB spirals. We briefly discuss these results in the context of the spectral evolution of spiral galaxies in general.

1 Observations

Low Surface Brightness spiral galaxies (LSBs) are generally late-type galaxies with blue central surface brightnesses fainter than $\sim$23 mag arcsec^{-2}. They usually display ill-defined spiral arms in the optical and contain only a few bright HII regions. Comparison of the chemical and optical properties of LSBs and HSB spirals reveals that LSBs are, on average, less luminous, bluer, metal-deficient, and more extended than HSBs [1], [4]. Furthermore, LSBs have lower HI surface densities and smaller dynamical masses within their optical radii than their HSB counterparts [2]. In this paper, we investigate the spectro-photometric and chemical properties of LSBs by means of a detailed galactic evolution model.

2 Model assumptions

We concentrate on the stellar contribution to the total galaxy luminosity in a given passband (other contributions are neglected). For a given star formation history (SFR), we compute the chemical enrichment of a model galaxy by successive generations of evolving stars. To derive the stellar luminosity in a given passband at a given age, we use an up-to-date metallicity dependent set of theoretical stellar isochrones as well as a library of spectro-photometric data. The spectro-photometric properties of the model galaxy are calculated by integrating the stellar luminosities at a given galactic age weighted with the SFR at the time these stars were born [6].

3 Results

We show in Fig. 1 model results for an exponentially decaying SFR$\propto \exp(-t/\tau_{\rm sfr})$ with $\tau_{\rm sfr} = 5$ Gyr (appropriate for the Galactic disk). We followed the chemical and spectro-photometric evolution of the model galaxy during the last 14 Gyr. A power-law IMF (slope -2.35) and initial stellar mass limits of 0.1 and 60 $M_\odot$ have been assumed.

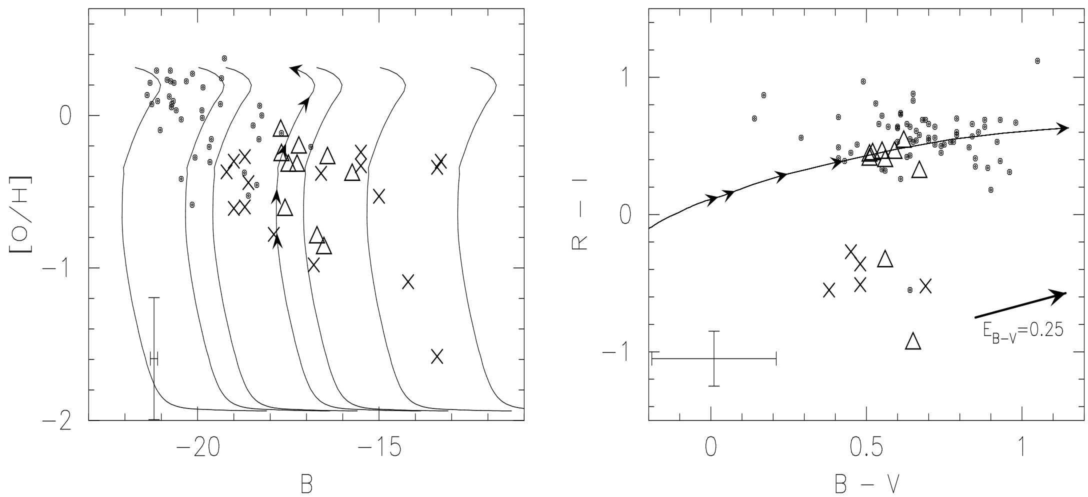

Figure 1: Resulting chemical and spectro-photometric evolution in the case of an exponentially decaying SFR (*solid curves*). *Left panel*: predicted [O/H] vs. B relation. Curves correspond to different initial galaxy masses in the range 10^7 to 5 10^{10} $M_\odot$. For the 10^9 $M_\odot$ model, arrows indicate evolution times of 1, 2, 4, 8, and 14 Gyr, respectively. *Right panel*: predicted $R-I$ vs. $B-V$ relation (independent of initial galaxy mass). Corrections for internal extinction will shift the model predictions in the direction indicated by the arrow. Symbols refer to the following galaxy types: face-on HSB spirals (dots [3]), LSB spiral galaxies (triangles [1]), and dwarf irregulars (crosses [5]). Observational errors are indicated in the bottom left corner.

4 Discussion and conclusion

We find that the colours and abundances of HSBs can be reasonably well explained by the decaying SFR model ending at a current gas-to-total mass-ratio of μ =0.1 (deviation from individual HSBs is partly due to the effects of dust-extinction). However, colours and [O/H] abundances predicted by the same models are inconsistent with observational data of LSBs, within the B-magnitude range appropriate for LSBs. These models clearly demonstrate that LSBs must have experienced their dominant episode of star formation much later in their evolution than HSBs. Furthermore, LSBs show [O/H] abundances considerably smaller than expected for values of $\mu \lesssim$0.15 which are suggested by the observations. This may indicate that: 1) LSBs experience predominantly star formation out of metal-deficient material not participating in the chemical enrichment of the disk, and/or 2) LSBs have much larger ratios μ than observed. Since detailed observations appear to rule out the second possibility [2], we conclude that metal-deficient gas infall is important in LSBs. In this case, recent and ongoing star formation in LSBs is required to maintain μ as low as 0.15.

References

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