

Summary of recent research activities

In the last couple of years I've been working on a few projects as PI, and at the same time I've continued collaborating with my expertise to other projects that were born in my pre-ESO years. Due to the limited space, it would not be possible to illustrate here all these research lines, so only some highlights will be given of investigations where I have a more prominent role. I grouped them in sections under a title that summarises the main idea.

THE EXISTENCE OF PRIMORDIAL GALAXIES The existence of dwarf galaxies with large reservoirs of gas and low chemical abundances make some researchers believe that these could be 'primordial' galaxies, in the sense of having started forming stars only a few hundred Myr ago. In this respect, I Zw 18 is still considered the best candidate, since it has the lowest oxygen abundance among galaxies in the local Universe ($\sim 1/50$ solar; Searle & Sargent 1972, ApJ 173, 25); however, the distance of the galaxy (> 10 Mpc) prevents the detection of the oldest stars and the issue is still open. Then at the end of the '90s I realized that the Sagittarius dwarf irregular (dIrr) galaxy (SagDIG) could also have a very low oxygen abundance and at the same time be close enough (~ 1 Mpc) to reach the red-giant branch (RGB) of the intermediate-old population (at that time no photometry had been published). Indeed new EFOSC2 spectra of its HII region yielded an oxygen abundance only slightly higher than that of I Zw 18 (Saviane et al. 2002), and our EMMI imaging revealed a well-defined RGB (Momany et al. 2002). However, the presence of carbon stars (Cook, unpublished PhD thesis) means that an intermediate-age population is present, and the RGB could be only a few Gyr old. Thus we applied for HST/ACS time, and the new CMD (Momany et al. 2005) finally reveals the horizontal branch of the old population; this demonstrates that **a metal-poor galaxy is not necessarily young**. A Hubble heritage issue was also dedicated to our SagDIG observations (<http://heritage.stsci.edu/2004/31/>). In the paper we also showed that a better reduction of the Izotov and Thuan (2004, ApJ 616, 768) data shows a hint of RGB tip in I Zw 18, and we plan to apply for deeper HST/ACS imaging in cycle 15 to finally settle this important issue.

THE LUMINOSITY-METALLICITY RELATION OF DIrr GALAXIES The very low oxygen content of SagDIG, despite a continuous SFH, could be due to galactic winds removing metals from the main body of the galaxy; indeed, for its oxygen abundance, a close-box model would predict a higher gas mass fraction than is observed, **a symptom that in fact SagDIG is an open box**. As a confirmation that this can happen, almost at the same time of the first SagDIG papers, a metal-enriched galactic wind was detected in NGC 1569 (Martin et al. 2002, ApJ, 574, 663), carrying a mass similar to the one we postulated for SagDIG (a few $10^6 M_{\odot}$). Since in the case of spheroidal galaxies galactic winds imprint a luminosity-metallicity (L-Z) relation (Larson 1974, MNRAS 169, 229), I decided to check if this is true for dIrr as well, and then to understand if the L-Z relation has the same origin. This is important to decide what is the role of dIrr galaxies in the enrichment of the intergalactic medium (IGM). At that time the issue was still debated, so I started a project to collect the best possible data to check the relation, i.e. homogeneous oxygen abundances of the gas and near-IR total luminosities; in parallel, I had surveyed a substantial fraction of the literature on dwarf galaxies for a review paper (Saviane et al. 2001), and that exercise showed how data for nearby groups of galaxies were sparse¹. Hence I had the idea to search for a L-Z relation using dIrr in nearby groups, thereby also checking the influence of different environments. Preliminary results of this project have been presented at the IAU Symposium 217 and IAU Colloquium 198 (Saviane et al. 2004, 2005) and a paper is in preparation: **a relation is definitely present for galaxies of the Sculptor group, but only if the abundances are measured in the central regions of each galaxy**. Unfortunately, adverse weather conditions did not allow to collect enough data for the M81 group, so a verification of the influence of environment is still pending. The interpretation of the L-Z relation is still preliminary, but it seems like more massive

¹ After starting working on nearby groups of galaxies, it became evident that a conference on this topic would have been welcome, since the previous two meetings had limited scope and they were several years back in time. A proposal was then submitted (together with V. Ivanov) and later accepted by ESO, and the meeting *Groups of galaxies in the nearby Universe* will be held in Chile in December 2005.

galaxies form stars more rapidly than low mass galaxies, so the relation could be a **combination of more effective winds and less effective astration as the mass decreases**. Recently, with one of the original project's collaborators (F. Bresolin) I also started a collaboration with John Salzer of the KISS project to obtain more data for giant star-forming galaxies. In fact their L-Z relation (Salzer et al. 2005, ApJ 624, 661) cannot be compared to ours since it uses empirical abundances, due to the fact that the temperature-sensitive line [OIII]4363 disappears at high metallicities. This shortcoming can be bypassed using Fabio's method to measure T_e (employing [SIII]6312, [NII]5755, and [SIII]9069 lines) so we will get direct abundances of some of the KISS targets using the Keck, and eventually compare the L-Z relation of low and high mass galaxies.

THE EXISTENCE OF TIDAL DWARF GALAXIES One place where really new born dwarf galaxies could be found, is the tidal debris of major mergers, as originally suggested by Zwicky (1956, *Ergeb. Exakten Naturwissen.*, 29, 344). Following this idea, Schweizer (1978, in *Structure and Properties of Nearby Galaxies*) proposed that a 'tidal dwarf galaxy' (TDG) is forming beyond the tip of the southern tail of the Antennae galaxies, but then Mirabel et al. (1992, A&A, 256, L19) claimed that the TDG is actually located where stars are forming inside the tail. To investigate this issue, I joined a project involving UCLA and NRAO researchers, that had HST/WFPC2 imaging of the Mirabel et al. TDG. The resulting paper (Saviane et al. 2004) showed that the region is a rather anonymous area with spontaneous star formation producing the kind of OB star associations seen in dwarf irregular galaxies. The computed SF rate of $6 \times 10^{-3} M_{\odot} \text{yr}^{-1}$ is also typical of dIrrs. But perhaps the most important result is a **downward revision of the distance to the Antennae**, through the detection of the RGB tip: I have found a value of 13.8 Mpc, while the traditional redshift distance is ~ 20 Mpc, based on a radial velocity of $\sim 1400 \text{ km sec}^{-1}$ and assuming $H_0 \sim 70$. Once more, this shows that, for objects within $\sim 7,000 \text{ km sec}^{-1}$, **distances based on the recession velocity can be in serious error** (e.g. Tonry et al. 2000, ApJ, 530, 625). The paper left the question of the existence of a TDG unsettled, since the candidate proposed by Schweizer (1978) lied outside the WFPC2 field of view: a proposal to carry out HST/ACS observations of this structure was then submitted and accepted for cycle 14, so now we plan to investigate if the SFH of this low surface brightness object is related to the interaction history of the two galaxies. A better constraint on the distance of the system will be obtained as well. The observations (7 orbits) are scheduled from Dec 28, 2005 to Jan 4, 2006.

A NEW MINOR MERGER IN THE MILKY WAY? After developing a pipeline for the semi-automatic reduction of HST/WFPC2 imaging of point sources (Piotto et al. 2002), I tested it on archival data of 7 old clusters of the LMC and surprisingly, I found that **one of the clusters is actually younger than the rest** (Saviane et al. 2003); it also turns out that NGC 1841 does not participate to the general rotation of the other LMC globulars, and it is the most distant from the center of the galaxy. Since most young clusters in the Galaxy are associated with minor mergers, I decided to look if any tidal stream can be detected in the vicinity of the cluster, mapping the surrounding area with WFI; at the same time, the control fields near the LMC will allow to investigate the stellar content of its halo. The data reductions are in progress in Padova.

DUST-ENSHROUDED AGBS IN THE LOCAL GROUP In the framework of the 'Padova survey of Local Group Galaxies' (Rizzi et al. 2003) we have collected SOFI data for Leo I, Leo II, Carina, and Fornax. All the resulting CMDs show an almost vertical sequence of AGB stars, which goes ~ 2 mag brighter than the RGB tip and then turns to an almost horizontal sequence that extends to the red from $(J - K) = 2$, where C-stars and dust-enshrouded AGB stars are found. Rather naturally, I proposed to get thermal infrared VISIR imaging of these obscured AGB star candidates, in order to extend the C-rich vs. O-rich classification to these objects. The observations are scheduled in November 2005, and with the SIV-PAH2 vs. PAH1-SIV and the K-PAH1 vs. H-K two-color diagrams we will be able to classify these objects as oxygen-rich or carbon-rich stars, and this classification will be the first step towards the creation of a complete census of AGB star subclasses in LG dwarfs, with the aim of calibrating the C-star fraction vs. mean metallicity and star-formation history. Eventually **the mass limits for the occurrence of carbon stars will be obtained**, and they will allow to increase the predictive power of stellar population synthesis models.

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