RevMexAA (Serie de Conferencias), **40**, 54–55 (2011)

THE ROLE OF TIDAL DWARF GALAXIES IN GALAXY EVOLUTION

D. F. de Mello,[1] C. Mendes de Oliveira,[2] S. Torres-Flores,[3] and F. Urrutia-Viscarra[2]

RESUMEN

A continuación presentamos un resumen del trabajo que hemos llevado a cabo en orden de entender el rol de las galaxias enanas de marea (GEMs) en la evolución de galaxias. GEMs son comúnmente vistas en sistemas en interacción. Estos objetos son jóvenes, los cuales son formados a partir de los residuos (gaseosos y estelares) resultantes de la interacción entre galaxias. Hemos usado una gran variedad de instrumentos, en diferentes longitudes de onda, para detectar las GEMs, así como también regiones de formación estelar dentro de colas de marea de hidrógeno neutro y con la ayuda de modelos de poblaciones estelares hemos estimado sus edades. También hemos determinado la metalicidad de algunas GEMs y hemos concluido que estos objetos tienen una metalicidad mayor que la presentada por galaxias enanas. Finalmente, discutimos la importancia de estos objetos en el universo distante y su importancia en el enriquecimiento químico de éste.

ABSTRACT

We present a summary of the recent work that we have been conducting regarding the role of Tidal Dwarf Galaxies (TDGs) in galaxy evolution. TDGs are often seen in galaxies going through collisions. They are young objects formed from and within tidal debris. We use a variety of instruments in different wavelengths (from UV to optical) to detect the TDGs and star-forming regions within HI tails and use stellar population models to date them. We also have determined the metallicity of a few of these objects and concluded that they are metal rich with respect to the population of dwarf galaxies. We conclude by discussing the importance of these objects at high-redshfits and their significance in the cosmic metal enrichment.

Key Words: H II regions — galaxies: dwarf — galaxies: interactions

1. INTRODUCTION

When galaxies collide and merge they suffer tidal effects that will transform their properties and will also affect their gas distribution. These collisions can produce dwarf galaxies within the tidal tails (TDGs). However, the importance of TDGs in terms of galaxy evolution is still debatable. It has been shown in early galaxy simulations (Barnes & Hernquist 1992; Elmegreen et al. 1992) that only the outermost material will gain enough angular momentum and energy to become an independent dwarf galaxy. More recently, Wetzstein et al. (2007) using high resolution N-body and N-body/SPH models showed that these earlier results were affected by the low resolution of the models. They concluded that tidal dwarf galaxies are not likely to form by pure collisionless collapse in tidal tails. The high resolution models require a sufficiently massive and extended gas component in the progenitor disk in order to form bound stellar objects in the tidal arms ($10^{8-9}\ M_\odot$). Bournaud et al. (2008) high resolution models of mergers showed the formation of less massive objects ($10^5\ M_\odot$), or super star clusters, which were interpreted as the progenitors of globular clusters. More massive objects ($10^{8-9}\ M_\odot$) also formed during collision of gas-rich galaxies and were interpreted as TDGs. However, it is not clear whether TDG production is related to the formation of dwarf galaxies, i.e., whether long-lived TDGs become dwarf galaxies. For instance, Delgado-Donate et al. (2003) survey of dwarf galaxy candidates in the vicinity of six strongly interacting galaxies concluded that field galaxy-galaxy interactions are likely to result in the formation of only a few long-lived TDGs. Thus a large sample is needed in order to verify the fraction of TDGs as a function of environment and how that correlates with the dwarf galaxy population. Members of our team have been searching for TDGs in the past few years and found a few candidates (Mendes de Oliveira et al. 2001; Torres-Flores et al. 2009). Below we describe two other studies illustrating our method to find TDGs and their properties.

[1]Catholic University of America, Washington and NASA's GSFC, DC 20064, USA (demello@cua.edu).
[2]Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, SP, Brazil.
[3]Departamento de Física, Universidad de La Serena, Chile.

2. RESULTS AND CONCLUSIONS

The first interacting system with extended HI tail we analyzed is HCG100, a compact group formed by four late-type galaxies at $v_\mathrm{R} = 5336$ km s^{-1}

($z = 0.0178$). GALEX FUV and NUV images of this group reveal that there are 15 sources located in the vicinity of the intergalactic HI clouds of the compact group which extend to over 130 kpc away from the main galaxies (de Mello et al. 2008). Figure 1 shows the Gemini images taking during the mask preparation of two of the UV sources. A tidal dwarf galaxy (#4 in Figure 1) is located in the densest region of the HI tail, ∼61 kpc from the brightest group member. A second candidate (#3 in Figure 1) is located at ∼120 kpc away from the main galaxies. They resemble dwarf irregulars and are ∼7–8 kpc in diameter. Object #4 contains clumps of ∼200 pc which we interpreted as large star-forming regions. For comparison, the nearest massive star-forming region in our galaxy, the Carina nebula (NGC 3372), and the very large OB association, NGC 604 in M33 have diameters ∼150 pc (Zinnecker & Yorke 2007) and ∼140 pc (Maiz-Apellaniz et al. 2004), respectively. The Gemini spectra of both objects (Urrutia-Viscarra et al. 2011) indicate that they have metallicities higher than local dwarf galaxies suggesting that these star-forming regions are formed from pre-enriched material that was ejected from the host galaxies into the intragroup medium.

We have also searched for TDGs outside the merger remnant, NGC 2782 (34 Mpc). This galaxy shows a prominent tidal tail detected in HI, located to the western side of the object. By using GALEX FUV and NUV imaging and HI data we found seven UV sources located at distances greater than 26 kpc from the center of NGC 2782, and coinciding with its western HI tidal tail (Torres-Flores et al. 2011). These objects have ages of 8 to 188 Myr and masses ranging from $10^{5.2}$ to $10^{6.8}$ $M_{\odot}$. Using GEMINI/GMOS r-band images we resolved each UV source in several smaller systems showing that they are not as large as TDGs but resemble small stellar clusters. Using Gemini/GMOS spectroscopic data we confirm that they are at the same distance as NGC 2782. Two of them have super solar metallicities which could be explained if they were formed out of highly enriched gas which was once expelled from the center of the merging galaxies when the system collided, whereas an inflow of low abundance gas from the outskirts of the merging galaxies could explain the comparably lower metallicity observed close to the central region of NGC 2782. An additional possibility is that the tail has been a nursery of a few generations of young stellar systems which ultimately polluted this medium with metals, further enriching the already pre-enriched gas ejected to the tail when the galaxies collided.

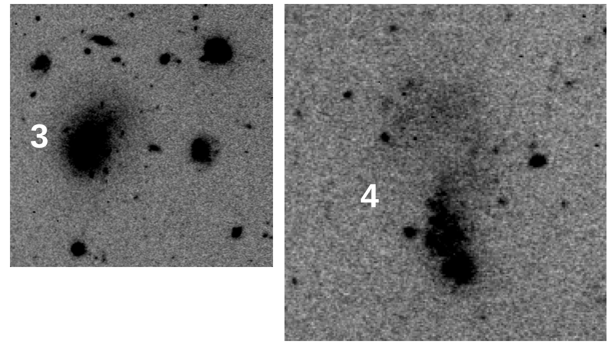

Fig. 1. Gemini/GMOS Image of the two new TDGs in the HCG100 HI tail.

The two systems we presented here host star formation outside the main galaxies. The less evolved system, HCG100, was able to form two tidal dwarf galaxies whereas the merger remnant formed less massive stellar clusters. The fate of these systems is unknown. However, they seem to be commonly found outside interacting systems. Small mass objects forming stars will be efficient pollutant of the intergalactic medium on large scales (Ferrara 2008). Therefore, these systems may play an important role in the cosmic metal enrichment. Moreover, the high-redshift Lyman Break Galaxies resemble small blue compact dwarf galaxies (Filkenstein et al. 2010) and TDGs might be their counterparts in the local universe.

REFERENCES

Barnes, J. E., & Hernquist, L. 1992, Nature, 360, 715
Bournaud, F., Duc, P.-A., & Emsellem, E. 2008, MNRAS, 389, 8
Delgado-Donate, E. J., et al. 2003, A&A, 402, 921
de Mello, D. F., Torres-Flores, S., & Mendes de Oliveira, C. 2008, AJ, 135, 319
Elmegreen, B. G., Kaufman, M., & Thomasson, M. 1992, ApJ, 412, 90
Ferrara, A. 2008, IAU Symp. 255, Low-Metallicity Star Formation, ed. L. K. Hunt, S. Madden, & R. Schneider (Cambridge: Cambridge Univ. Press), 86
Finkelstein, S. L., et al. 2010, ApJ, 719, 1250
Maiz-Apellaniz, J., et al. 2004, AJ, 128, 1196
Mendes de Oliveira, C., Plana, H., Amram, P., Balkowski, C., & Bolte, M. 2001, AJ, 121, 2524
Torres-Flores, S., et al. 2009, A&A, 507, 723
Torres-Flores, S., Mendes de Oliveira, C., de Mello, D. F., & Urrutia-Viscarra, F. 2011, submitted
Urrutia-Viscarra, F., Mendes de Oliveira, C., de Mello, D. F., Torres-Flores S., & Carrasco, R. 2011, submitted
Wetzstein, M., Naab, T., & Burket, A. 2007, MNRAS, 375, 805
Zinnecker, H., & Yorke, H. W. 2007, ARA&A, 45, 481