Boletim da Sociedade Astronômica Brasileira, **33**, no. 1, 81-82

Testing the correlation between mergers and AGN in the Arp 245 system

Elismar Lösch & Daniel Ruschel-Dutra

[1] Departamento de Física/CFM, Universidade Federal de Santa Catarina; e-mail: elismar@astro.ufsc.br

Abstract. Mergers are decisive processes which occur frequently during the evolution of galaxies and may be correlated with extreme phenomena such as starbursts and active galactic nuclei (AGN). In order to investigate the influence of the mergers on the nuclear activity, we are performing a case study of the interacting system Arp 245, which hosts the active spiral NGC 2992 together with spiral NGC 2993. We employ numerical hydrodynamical simulations to reproduce the merger and analyze the gas inflow and the consequent luminosity of an AGN being fed that quantity of gas during the interaction. At first, we perform an exploration of parameter space through simulations available at the GalMer database. But in order to achieve a more accurate set of initial conditions for the simulation, we are currently working with the morphological and orbital description of Arp 245 through observational constraints.

Resumo. Mergers são processos decisivos que ocorrem com frequência durante a evolução das galáxias, podendo estar correlacionados com fenômenos extremos como surtos de formação estelar e núcleos ativos de galáxia (AGNs). Para investigar a influência do mergers sobre a atividade nuclear de galáxias, estamos realizando um estudo de caso do sistema em interação Arp 245, que hospeda a galáxia espiral ativa NGC 2992, e a também espiral NGC 2993. Empregamos simulações numéricas hidrodinâmicas para reproduzir o merger e analisar o inflow de gás e a consequente luminosidade de um AGN sendo alimentado com esse gás durante a interação. Num primeiro momento, realizamos uma exploração do espaço de parâmetros através de simulações disponibilizadas na biblioteca GalMer. Porém, para a obtenção de um conjunto de condições iniciais mais precisas para a simulação, estamos trabalhando atualmente na descrição morfológica e orbital do Arp 245 através de vínculos observacionais.

Keywords. Galaxies: interactions – Galaxies: active– Methods: numerical

1. Introduction

Mergers are some of the most disruptive events that can occur during the evolution of a galaxy and are among the main mechanisms which can cause an inflow of gas to galactic centers, resulting in phenomena such as starbursts and active galactic nuclei (AGN) (e.g. Mihos and Hernquist 1994).

Many uncertainties are still present in the discussion about the influence of mergers on AGN when compared to secular processes of galaxies, such as bars (Regan and Teuben 2004), galaxy disk instabilities (Bournaud et al. 2011) and cosmological gas fluxes (Feng et al. 2014), all of which can also feed gas to the supermassive black hole (SMBH) of galaxies in different scenarios, triggering the nuclear activity.

In order to investigate in detail the influence of a major merger on the nuclear activity of the galaxies involved, we performed a case study of the interacting pair Arp 245 (Figure 1), a system hosting the spirals NGC 2992 and NGC 2993. The former is most widely known for its very active SMBH, recently classified as a Seyfert 1.8 by Schnorr-Müller et al. (2016), making this system an ideal target for our study.

For this work we employ a numerical approach, studying the inflow of interstellar gas to the central regions of the galaxies through simulations of galaxy mergers resembling the Arp 245 system. Here, we present our preliminary results derived from simulations provided by the GalMer database (Chilingarian et al. 2010), as well as our current search for the morphological and orbital parameters of the galaxies in order to build a new, more reliable simulation of Arp 245.

2. First Results

For a first exploration of parameter space of the Arp 245 system, we studied three different simulations of major mergers available at the GalMer database[1] which most resembled the system in terms of morphology and mass of the galaxies, in prograde, keplerian orbits, and with an angle of 75° between the spin vectors of the galaxies. The only difference is on the orbital angular momentum (l) of each simulated system. We call them orbit type 1 simulation (l_1 = 56.6 $km\ kpc\ s^{-1}$), orbit type 5 (l_2 = 80.0 $km\ kpc\ s^{-1}$) and orbit type 9 (l_3 = 97.9 $km\ kpc\ s^{-1}$).

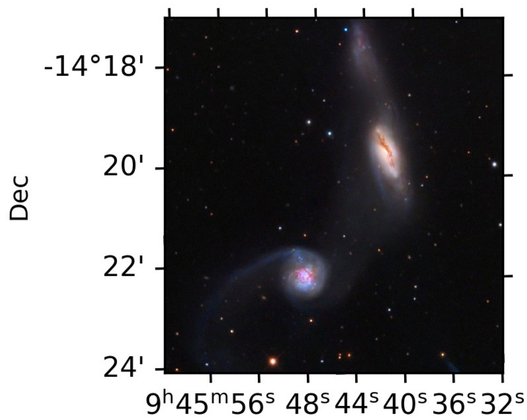

Figure 1. LRGB image composition of Arp 245 from Block (2011)

For each of these simulated mergers we estimated the luminosity of an AGN with a positive inflow of gas through a spherical surface of radius 10 pc around galactic centers (Figure 2), considering an efficiency of 10% for the mass-energy conversion power of the AGN.

[1] http://galmer.obspm.fr/

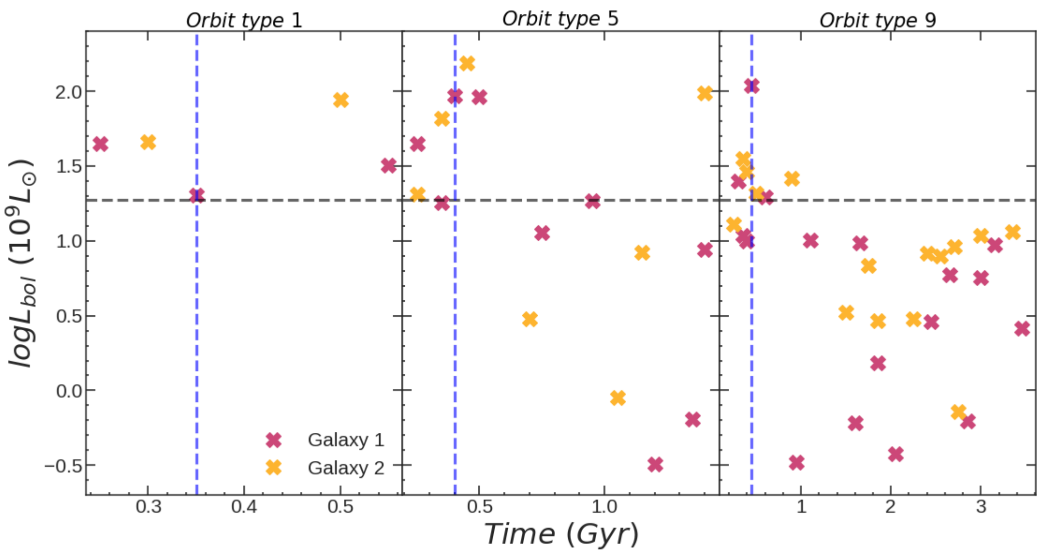

FIGURE 2. Luminosities of an AGN considering 100transportation efficiency from 10pc down to the SMBH at the centre of the simulated galaxies compared to the bolometric luminosity of NGC 2992' AGN (horizontal dashed line). Vertical dashed lines mark the perigalacticons.

Comparing it to the bolometric luminosity of NGC 2992's AGN, we concluded that an interaction similar to that happening in Arp 245 does indeed cause an inflow of gas to the inner regions of the galaxies which is sufficient to explain the observed luminosity of the AGN.

3. In search for morphological and orbital parameters for the galaxies

We are now in search of a more complete description of the morphology and orbit of the galaxies in order to build a new, more accurate simulation of Arp 245.

The galaxies in our models are formed by four components: a stellar disk, a gas disk, a stellar bulge and a dark matter halo. The disks follow an exponential density profile with a $\text{sech}^2(z)$ vertical component:

$$\rho(R,z) = \frac{M}{4\pi R_d^2 z_0} \exp\left(\frac{-R}{R_d}\right) \text{sech}^2\left(\frac{z}{z_0}\right) \quad (1)$$

where M is the total mass of the component, R_d is a radial scale length, and z_0 a vertical scale length.

The sheroidal components — bulge and dark matter halo —, on the other hand, follow the Hernquist (1990) profile

$$\rho(r) = \frac{M}{2\pi} \frac{a}{r} \frac{1}{(r+a)^3} \quad (2)$$

in which we have again the total mass M of the component and a scale length a.

The radial scale length (R_d) of the stellar disk and scale parameter (a) of the bulge were obtained directly from a brightness profile fit of the galaxies, while the vertical scale length (z_0) of the stellar disk comes from the relation between the central surface brigthness (S_0) and the fraction ($\frac{z_0}{R_d}$) established by Bizyaev and Mitronova (2002). By means of an appropriate light-to-mass ratio, we also obtained the total masses for these two stellar components.

The total gas mass comes from the 21cm-line emission of the galaxies, while its scale parameters are set by the physics of gas during the simulations. Finally, the parameters of the dark matter halo are derived from the rotation curves of the galaxies.

We are currently looking for the orbital parameters of the system. For this we employ the QUEORBITA algorithm[2], which takes a predefined range of eccentricities and pericentral distances for the orbits, in addition to information like total masses and spin vectors of the galaxies, returning all orbits satisfying observational constraints such as relative radial velocity and relative projected distance between the galaxies.

This method yielded 23538 possible orbits for Arp 245, but just a few of them are able to adequately match the kinematics of the the system at the current state of the interaction and reproduce the tidal features observed in Arp 245. The initial conditions for our next simulations will be drawn from one of those orbits.

References

Bizyaev, D. and S. Mitronova (2002, July). Photometric parameters of edge-on galaxies from 2MASS observations. *A&A 389*, 795–801.
Block, A. (2011). *Caelum-Observatory:NGC2992.*
Bournaud, F., A. Dekel, R. Teyssier, M. Cacciato, E. Daddi, S. Juneau, and F. Shankar (2011, November). Black Hole Growth and Active Galactic Nuclei Obscuration by Instability-driven Inflows in High-redshift Disk Galaxies Fed by Cold Streams. *ApJ 741*(2), L33.
Chilingarian, I. V., P. Di Matteo, F. Combes, et al. (2010, Jul). The GalMer database: galaxy mergers in the virtual observatory. *A&A 518*, A61.
Feng, Y., T. Di Matteo, R. Croft, and N. Khand ai (2014, May). High-redshift supermassive black holes: accretion through cold flows. *MNRAS 440*(2), 1865–1879.
Hernquist, L. (1990, June). An Analytical Model for Spherical Galaxies and Bulges. *ApJ 356*, 359.
Mihos, J. C. and L. Hernquist (1994, August). Ultraluminous Starbursts in Major Mergers. *ApJ 431*, L9.
Regan, M. W. and P. J. Teuben (2004, January). Bar-driven Mass Inflow: How Bar Characteristics Affect the Inflow. *ApJ 600*(2), 595–612.
Schnorr-Müller, A., R. I. Davies, K. T. Korista, et al. (2016, November). Constraints on the broad-line region properties and extinction in local Seyferts. *MNRAS 462*(4), 3570–3590.

[2] Irapuan Rodrigues, 1999