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KINEMATICS OF THE NUCLEAR REGION OF M83

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RESUMEN

La enorme generación de energía detectada en muchos núcleos de galaxias representa uno de los temas clave de los estudios de galaxias y de su evolución, a pesar de lo cual varias cuestiones permanecen sin resolver: ¿Son la acreción sobre agujeros negros supermasivos y la violenta formación de estrellas sólo fenómenos coevolventes o son socios necesarios en la actividad? ¿¿Cómo es la física detallada de los mecanismos que provocan la violenta formación de estrellas en el núcleo extendido? ¿Cuál es la relación de los mecanismos detonadores con la evolución de galaxias? La principal desventaja para enfrentar estas cuestiones es que las etapas desarrolladas de grandes eventos de formación estelar en los centros galácticos no proporcionan suficientes claves sobre su origen, ya que los indicios morfológicos de los mecanismos detonadores son borrados en escalas de tiempo de unas cuantas revoluciones orbitales del núcleo galáctico. Aquí presentamos el comienzo de un evento así, experimentado por M 83, una galaxia lo suficientemente cercana para permitir llevar a cabo detallados estudios espaciales cinemáticos y morfológicos. La espectroscopía 3D de alta resolución del IR cercano sugiere la captura de una galaxia satélite cuya excitación dejó atrás de sí un arco nuclear gigante de formación estelar violenta. El gradiente de edad dentro del arco apoya el hecho de que ésta estructura sigue el camino orbital del intruso. Nuestro modelado numérico indica que los dos núcleos se unirían en menos de 50 50 Myr (Maños).

ABSTRACT

The enormous energy output detected in many cores of galaxies is one of the key issues in the studies of galaxies and their evolution, notwithstanding several questions remain unsolved: Are accretion onto super-massive black holes and violent star formation just coevolving phenomena or necessary partners of the activity? How is the detailed physics of the mechanisms triggering the nuclear extended violent star formation? Which is the relationship of the triggering mechanisms with galaxy evolution? The main drawback to face these issues is that developed stages of large star formation events at galactic centres do not provide enough clues about their origin, since the morphological signatures of the triggering mechanism are smeared out in the time scale of a few orbital revolutions of the galaxy core. Here we present the onset of such an event undergone by M 83, a galaxy nearby enough to allow detailed spatial cinematic and morphological studies. High resolution 3D near-IR spectroscopy sugests the capture of a satellite galaxy, whose spur left behind a giant nuclear arc of violent star formation. The age gradient within the arc supports that this structure traces the orbital path of the intruder. Our numerical modelling indicates that the two nuclei would coalesce in less than 50 Myr.

Key Words: **GALAXIES: INDIVIDUAL: (M83) — GALAXIES: SPIRAL**

1. INTRODUCTION

M83 is a nearby grand design spiral galaxy (D= 3.7Mpc: de Vaucouleurs et al. 1991). Despite of the several observational studies, the dynamical origin of its nuclear starburst has remained elusive (Rogstad et al. 1974; Elmegreen et al. 1998; Gallais et al. 1991). Long slit observations (Thatte et al. 2000) revealed two peaks in the slit profile of the stellar radial velocity dispersion, interpreted as the presence of two dynamical centres. The existence of two off-centred nuclei, one of them coincident with the optical nucleus and the other located a few arcseconds to the west of the optical nucleus, was proposed (Mast et al. 2002). A deep photometric study (Harris et al. 2001) of the 45 most massive clusters in the giant star forming arc (see Figure 1) shows that starburst began less than 10 Myr ago and the clusters may dissolve on a 10 Myr timescale.

2. OBSERVATIONS AND SIMULATIONS

We carried out sub-arcsecond spatial resolution 3D spectroscopy, using CIRPASS instrument at the GENIMI south telescope. Figure 2 shows the radial velocity field of the ionised gas. It is clear that the main rotation centre is far from the optical nucleus.

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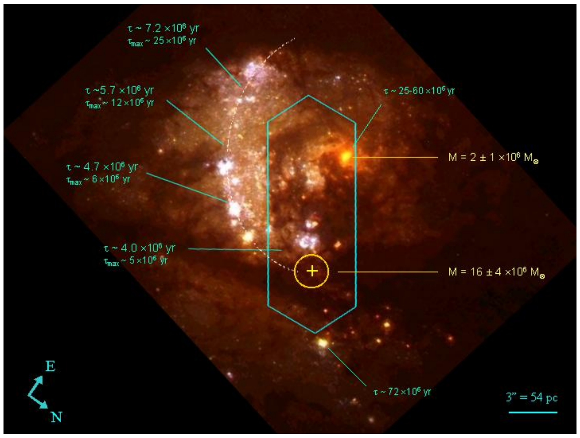

Fig. 1. HST pseudo colour optical image. The average ages of the young massive star clusters (Harris et al. 2001) in the arc (in 25^o angular sectors), are depicted together with the age of the oldest clusters in each sector. The field observed with the GEMINI/CIRPASS is shown (blue polygon), as well as the position of the main rotation centre (yellow circle). The red features in the image inside the integral field area can be compared with the J-band continuum image in Figure 2. The main rotation centre (intruder nucleus) is at the youngest end of the giant star forming arc. Coincidently, the dynamical crossing time at this scale is about 5 Myr.

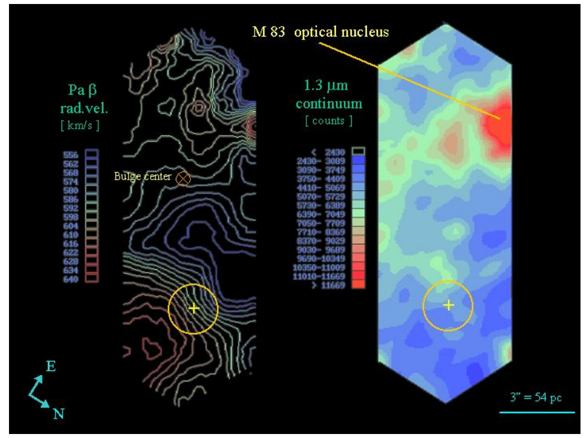

Fig. 2. Left: Radial velocity map of the ionised gas (Paβ line), showing the optical and the hidden nuclei. The step in isovelocity lines was fixed equal to the average uncertainty, but the shape of the field does not qualitatively change even at a 3 sigma display. Right: J-band image generated from the continuum emission (resolution is 0.6").

The hypothesis that it corresponds to a satellite accreted into the gaseous circumnuclear environment of M83 is supported by a series of observational evidences: i) the hidden mass concentration is at the youngest end of the starburst arc (Figure1); ii) The continuum maps at radio wavelengths (Telesco 1988) and at 10μm (Thatte et al. 2000) have a strong tidal appearance, with the largest emission at mid-IR located precisely at the position of the dark mass; iii) the age of the oldest clusters in the starburst arc is similar to the dynamical crossing time of the central kpc; iv) the age difference between the youngest and the oldest ends of the arc (a few Myr) is similar to the dynamical crossing time at a 100pc scale in M83.

In order to study the dynamical evolution under this scenario, we simulated the encounter between the main system components, following the evolution of their stellar and gaseous contents using GADGET (Springel 2005). The system was modeled by 3 components (disks), constructed following the observed sizes, masses, and radial velocity distributions. They are: a disk, representing the inner part of M83 bulge ($2 \times 10^8 M_\odot$), the optical nucleus ($2 \times 10^6 M_\odot$) and the intruder nucleus ($16 \times 10^6 M_\odot$). A total of 100,000 particles was used and different orbits have been tested.

The main result of the simulation is that the galaxy nucleus, the optical nucleus and the intruder mass would form a single massive core in 23 Myr. Considering the range of uncertainties in the orbit determination, we can state that this massive core would finally settle as the new nucleus of M 83 in less than 50 Myr, implying a net grow of the central galactic mass. Furthermore, the whole star formation and nuclei merging event would last less than a global galactic revolution (about 150 Myr at the average radius of 5 kpc).

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