Wolf-Rayet and interactions features in the galaxy IRAS 08339+6517

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ABSTRACT

IRAS 08339+6517 is a Lyα emitting starburst galaxy that posses a **dwarf companion object** at 56 kpc. Recently, a H I tidal tail has been detected between them. We present deep broad band R and V and narrow band Hα CCD images as well as optical intermediate-resolution spectroscopy of both galaxies. The images reveal **interaction features** between both system and strong Hα emission in the inner part of IRAS 08339+6517. We report **the first detection of Wolf-Rayet features** in the spectrum of this galaxy. We also analyze the kinematics and the chemical composition of the ionized gas.

THE GALAXY IRAS 08339+6517

Figure 1. RGB image of the system obtained combining our V (in blue), R (in green) and Hα (in red) images.

IRAS 08339+6517 was firstly reported in the IRAS (InfraRed Astronomical Satellite) Point Source Catalog (1986) as a luminous infrared galaxy. It is at 80 Mpc (consequently, 1" = 388 pc). Margon et al (1988) and González-Delgado et al. (1998) describe it as young compact and exceptionally bright starburst nucleus.

Canon et al. (2004) presented a **VLA H I imaging** of the galaxy, finding an extended tidal structure in neutral hydrogen that indicates that it is interacting with a nearby companion located at 2.4' (56 kpc) to the NW, 2MASX J08380769+6508579, They estimated that around **70 % of the neutral gas of the system has been removed** from one or both galaxies.

OPTICAL IMAGERY

In **Figure 2** we show our final **R image** that is saturated to stress the faintest structures. This deep image reveals a **disturbed morphology in the external areas**: a long arc connecting the north of the galaxy with a bright ray at the south, and a **very diffuse plume** in the direction of the companion galaxy. This plume coincides with the beginning of the tidal H I material discovered by Cannon et al. (2004) between both galaxies (indicated by black contours). IRAS 08339+6517 has a circular morphology, indicating that it is nearly side-on. It shows bluer V-R color that the companion galaxy.

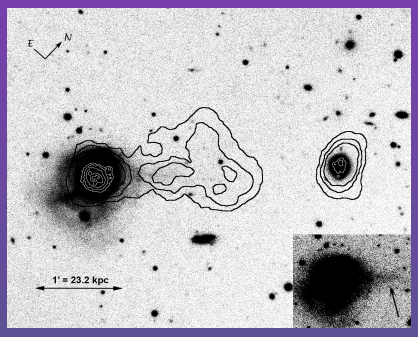

Figure 2. Deep R image of the system, in logarithmic scale. The white contours show the Hα emission (see Figure 3) and the black contours correspond to the H I map presented by Cannon et al. (2004).

OPTICAL SPECTROSCOPY

In **Figure 4** we show the calibrated **spectrum** of IRAS 08339+6517 between 4300 and 5200 Å. We derived the reddening constant, **C(Hβ),** and the equivalent width, **Wabs**, of the absorption in Balmer lines interactively to correct for interstellar reddening. Although the [O III] 4363 Å emission line is detected, the underlying stellar absorption presented in Balmer lines does not permit a proper measurement of this weak emission line. Consequently, the oxygen abundance was derived using the Pilyugin (2001) empirical calibration. The electron temperatures have been estimated from the T[O III] and T[O II] pairs that reproduce the total oxygen abundance obtained applying this empirical method. The **O/H and the N^+/O^+ ratio of both galaxies are rather similar** (see **Table 1**), suggesting that they have suffered a **similar chemical evolution** despite their different absolute magnitudes.

The spectrum of IRAS 08339+6517 shows the **weak He II 4686 Å** emission line, indicating the presence of **WR stars** in this starburst galaxy. It is the first time that this feature is detected in this galaxy. We have estimated **WR/(WR+O) = 0.03** and an **age between 5 and 6 Myr** using the evolutionary synthesis models for O and WR populations in young starbursts of Schaerer & Vacca (1998). Stasinska et al. (2001) and STARBURSTS 99 (Leitherer et al. 1999) models confirm this age, that is also similar to the one derived for the companion galaxy.

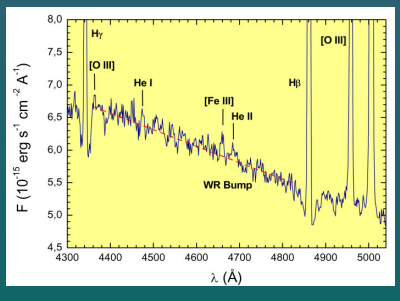

Figure 4. Part of the spectrum of IRAS 08339+6517 between 4300 and 5200 Å showing the He II 4686 Å emission line

OUR OBSERVATIONS

We have performed deep **broad R and V** as well as **narrow Hα** CCD images and optical intermediate-resolution spectroscopy of IRAS 08339+6517 and its companion galaxy. These observation were taken on 2004 March 20 at the 2.56m **Nordic Optical Telescope** (NOT) at Roque de los Muchachos Observatory (La Palma, Canary Islands, Spain) using the **ALFOSC** (Andalucía Faint Object Spectrograph and Camera) instrument. The **slit** was situated crossing the center of both galaxies. The **seeing** was ~ 0.8".

GALAXY	IRAS 08339+6517	Companion object 2MASX J08380769+6508579
$M_{V,0}$ $m_{V,0}$ $(V-R)_0$	− 20.80 ± 0.09 13.72 ± 0.09 0.16 ± 0.09	− 18.28 ± 0.08 16.24 ± 0.08 0.39 ± 0.09
C(Hβ) W_{abs}	0.26 ± 0.03 1.4 ± 0.1	0.18 ± 0.03 1.5 ± 0.1
T_e[O III] (K) T_e[O II] (K) N_e (cm^{-3})	9750 9825 100	10600 10420 100
12 + log O/H log N^+/O^+ Z / $Z_\odot$	8.47 ± 0.10 − 1.10 0.60	8.40 ± 0.10 − 1.33 0.51
Age (Myr)	5 – 6	5.5 – 6.5
$F_{H\alpha}$ (erg s^{-1} cm^{-2}) $L_{H\alpha}$ (erg s^{-1}) $SFR_{H\alpha}$ ($M_\odot$ yr^{-1}) $M_{H\,II}$ ($M_\odot$)	(1.53 ± 0.07) × 10^{-12} (1.17 ± 0.06) × 10^{42} 9.3 ± 0.5 (1.41 ± 0.07) × 10^7	(2.8 ± 0.3) × 10^{-14} (2.1 ± 0.2) × 10^{40} 0.17 ± 0.02 (2.6 ± 0.3) × 10^5
ΔV_r (km s^{-1}) M_{kep} ($M_\odot$) $M_{H\,I}$ ($M_\odot$) M_{kep} / $M_{H\,I}$ $M_{H\,II}$ / $M_{H\,I}$	0 (10 ± 3) × 10^9 (1.1 ± 0.2) × 10^9 9.1 0.013	20 ±10 (8 ± 2) × 10^8 (7.0 ± 0.9) × 10^8 1.1 0.0004

Table 1. General properties of both galaxies. The magnitudes have been corrected for reddening. The abundances were computed using Pilyugin (2001) empirical calibration. $Z_\odot$ from Allende Prieto et al. (2001). The H I masses were given by Cannon et al (2004).

CONCLUSIONS

Our new imagery and spectroscopic optical data of the galaxy IRAS 08339+6517 and its companion has revealed further evidences of the interaction between both objects as optical arcs and plumes and kinematical signatures. Their O/H an N/O ratios are rather similar, suggesting a common chemical evolution of the pair. The finding of the WR features in the spectrum of the main galaxy indicates that the starburst is very young (around 6 Myr). We have derived the SFR and keplerian and ionized masses of both galaxies.

REFERENCES

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- Stasinska et al. 2001, A&A 370, 1

HαIMAGERY

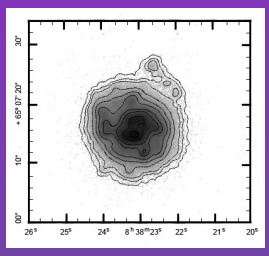

Figure 3. Continuum-substracted Hα image of IRAS 08339+6517.

The **Hα map** of IRAS 08339+6517 is shown in **Figure 3**. Several star-formation knots are found inside the disk, being the central the brightest. The NW side shows an arm with three knots of weak Hα emission. The **companion galaxy is weaker in Hα** emission. Its Hα morphology is irregular and splitted in several weak star-forming knots.

In **Table 1** we show the flux and the luminosity of the integrated Hα emission of both systems. We have corrected them of [N II] contamination and reddening. We have also derived the **star formation rate (SFR)** and the **mass of the ionized gas, $M_{H\,II}$**, using Kennicutt's (1998) calibrations. We find **$SFR_{H\alpha}$ = 9.3 $M_\odot$ yr^{-1}**, that it is in agreement with the one derived using the infrared flux from IRAF satellite, SFR_{IR} = 9.7 $M_\odot$ yr^{-1}. From the 1.4 GHz luminosity we find $SFR_{1.4GHz}$ = 30.7 $M_\odot$ yr^{-1}, indicating that the rate of the ongoing star formation is larger as a consequence of the most recent starburst.

THE KINEMATICS OF THE SYSTEM

In **Figure 5** we show the position-velocity diagram obtained from the long-slit spectrum. All the velocities are referred to the mean heliocentric velocity of the center of IRAS 08339+6517 (5730 km s^{-1}). The main galaxy has **an apparent global rotation pattern** although it is almost edge on, but it also shows a **sinusoidal behaviour** that could be produced by distortions in the gas associated with interaction effects. The interaction features are also detected in the outer areas, where the ionized gas presents a continuous variation up to +130 km s^{-1}. These positions coincide with the Hα emission detected in the NW arm. The central zones of the companion galaxy show also an apparent rotation behaviour, although important deviations from it (around +200 km s^{-1}) are found in the side opposites the main galaxy.

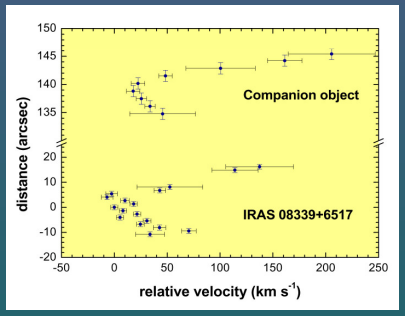

Figure 5. Position-velocity diagram for the slit position observed. NW is up.

Assuming the global kinematics of the galaxies as **circular rotation**, we can estimate their Keplerian mass, M_{kep}. These values are indicated in **Table 1**. When we compared the Keplerian mass, the neutral gas mass, $M_{H\,I}$, and the ionized hydrogen mass, $M_{H\,II}$, we find substantial differences between both galaxies. **IRAS 08339+6517 has higher $M_{H\,II}$ / $M_{H\,I}$ and M_{kep} / $M_{H\,I}$ ratios**, suggesting that it has transformed more efficiently its neutral gas to ioni-zed gas and stars. However, if we consider that the tidal H I gas, with a mass of $M_{H\,I}$=(3.8 ± 0.5) × 10^9, (Cannon et al. 2004), have been expelled from the main galaxy, the corresponding M_{kep} / $M_{H\,I}$ ratio is 2.0, more similar to the one found in the com-panion galaxy.