Boletim da Sociedade Astronômica Brasileira, **31**, no. 1, 143-144

Optical classification of OH megamaser galaxies

The cases of IRAS15587+1609 and IRAS11506−3851

Lara M. Gatto[1], Dinalva A. Sales[1], Andrew Robinson[2], Christopher O'Dea[3], Stefi Baum[3], Jack Gallimore[4], & Thaisa Storchi-Bergmann[5]

[1] Universidade Federal do Rio Grande, Rio Grande, Brasil e-mail: laragatto01@gmail.com, e-mail: dinalvaires@gmail.com
[2] Rochester Institute of Technology, Rochester, NY, USA, e-mail: axrsps@rit.edu
[3] University of Manitoba, Winnipeg, Canada, e-mail: odeac@umanitoba.ca, Stefi.Baum@umanitoba.ca
[4] Bucknell University, Lewisburg, PA, USA, e-mail: jack.gallimore@bucknell.edu
[5] Departamento de Astronomia, Universidade Federal do Rio Grande do Sul. 9500, Porto Alegre, 91501-970, Brazil, e-mail: thaisa@ufrgs.br

Abstract. We present an optical study of the OH Megamaser Galaxies (OHMGs) IRAS15587+1609 and IRAS11506−3851 using spectroscopy data obtained with the Gemini Multi-Object Spectrograph (GMOS) as well as Hubble Space Telescope (HST) *i* band (F814W) images. Our HST *i* band images show that IRAS15587+1609 is a double interacting system, while IRAS11506−3751 is a spiral galaxy with numerous compact regions of ongoing circum-nuclear star formation. The spectral diagnostics reveal that the interacting pair of the IRAS15587+1609 system are both HII galaxies. The IRAS11506−3751 system has a central source dominated by a strong active galactic nucleus (AGN) and its circum-nuclear region shows evidence of shock ionization driven by either starburst super winds or by galaxy collisions.

Resumo. Este trabalho mostra um estudo de duas galáxias Megamaser de OH (OHMGs), IRAS15587+1609 e IRAS11506−3851, em comprimento de onda do óptico. Foi usado dados espectroscópicos observados com o Gemini Multi-Object Spectrograph (GMOS) e imagens na banda *i* (F814W) do Hubble Space Telescope (HST). A imagem na banda *i* da IRAS15587+1609 mostra que esse é um sistema duplo interatuante e a IRAS11506−3751 é uma galáxia espiral com numerosas regiões compactas de formação estelar circum-nuclear. Usando diagrama de diagnóstico foi posível concluir que ambos núcleos do sistema IRAS15587+1609 são galáxias HII, e o sistema IRAS11506−3751 hospeda um intensa fonte de ionização não estelar, núcleo ativo (AGN), circundado por formação estelar e ionização por choques oriundo de interação e/ou super ventos de atividade starburst.

Keywords. Galaxies: interactions – Galaxies: active – Galaxies: individual: IRAS15587+1609, IRAS11506−3751 – Line: identification – Masers – Radio continuum: galaxies

1. Introduction

OH Megamaser Galaxies (OHMGs) form a sub-class accounting for approximately 20% of (Ultra-)Luminous Infrared Galaxies ([U]LIRGs), which emit OH maser lines at 1665 and 1667 MHz with luminosities $\sim 10^{2-4}$ $L_\odot$ (Lo 2005). As these galaxies are found in gas-rich mergers, it has been suggested that OHMs can be used to trace galaxy merger rates and associated processes (dust obscured star formation and black hole growth) over a wide redshift range (e.g. (Lo 2005), and references therein). Frequently, the OH maser emission is found in galaxies with high concentrations of dense, $n(H_2) = 10^{5-7}cm^{-3}$ molecular gas, sometimes in edge-on rotating disks or rings on scales of $<$ 100pc. In addition, the OH lines often show broad asymmetric profiles and velocity shifts suggestive of outflows (Bann, Haschick, & Henkel 1989; Rovilos et al. 2002; Parra et al. 2005; Momjian et al. 2006). Keeping this in mind, OHMGs may therefore represent a critical, short-lived transition phase in which massive, dense concentrations of molecular gas are triggering intense episodes of star formation and the onset of AGN fueling, resulting in rapid black-hole growth.

One outstanding question is whether starburst or AGNs are the dominant sources of dust and gas heating, hence, the main goal of this study is investigate the dominant excitation mechanisms of the two OHMGs, IRAS15587+1609 and IRAS11506−3851 in relation to their merger stage. We used optical spectroscopic data obtained with the Gemini Multi-Object Spectrograph (GMOS) as well as *i* band (F814W) images taken with the Hubble Space Telescope (HST). From this we aim to analyze their large scale morphology and to derive the relative contribution of AGN and/or Starburst activities using optical spectral diagnostic diagrams.

2. Observation and data reduction

The optical spectroscopy observations were obtained by Gemini/GMOS, through project GS-2013B-Q-90 (PI: Dinalva A. Sales). The data were taken in long-slit mode with a 1″ slit width. IRAS15587+1609 was observed using the Gemini South (GS) telescope and the Position Angle (PA) of the long-slit was 30° (see Fig. 1). IRAS11506−3851 was also observed by GS, and the P.A. of the long-slit was 59° (see Fig. 1).

The spectroscopic data reduction was performed using the Image Reduction and Analysis Facility (IRAF) software, along with the sub-packages developed for specifically the Gemini/GMOS instrument. We present extracted spectra of IRAS15587+1609 and IRAS11506−3851 in Fig. 2.

3. Results

From Fig. 1 we clearly see that IRAS15587+1609 system is an interacting pair of galaxies. We can also see that IRAS11506−3851 has a very extended spiral morphology with extensive circum-nuclear star forming regions. Therefore,

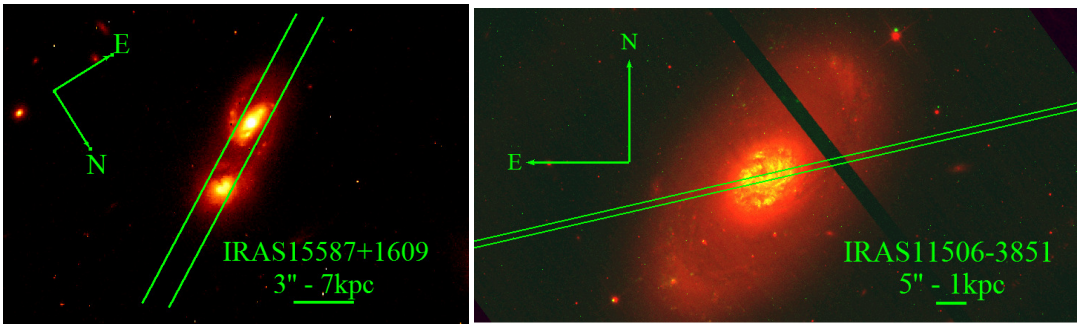

Figure 1. Left-panel: HST ACS F814W (i band) image of IRAS15587+1609. Right-panel: composite image of IRAS11506−3851 constructed with SDSS 4680Å (red), HST F814W (green) and HST Hα+[N II] (yellow) images (Sales et al. in prep.)

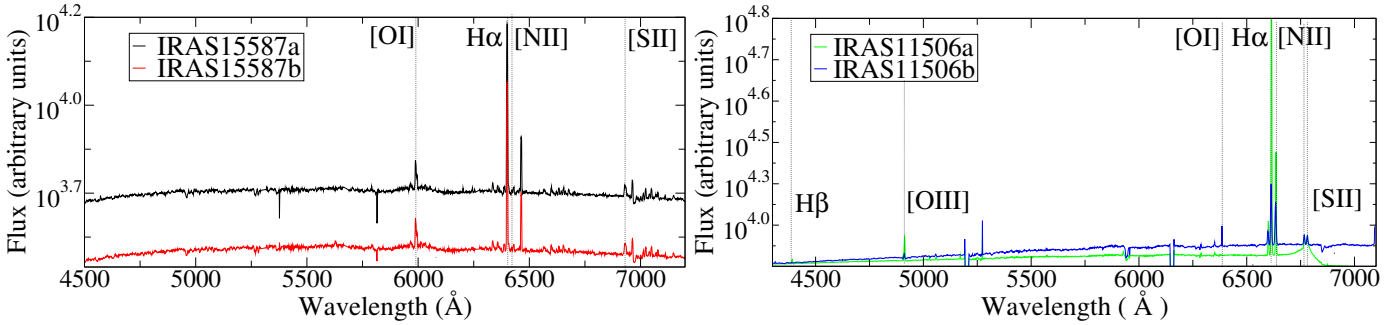

Figure 2. Left-panel: extracted one-dimensional spectra of the East (IRAS15587a; black) and North-West (IRAS15587b; red) nuclei of the IRAS15587+1609 system. Right-panel: extracted one-dimensional spectra of a circum-nuclear star forming region North-West of the nucleus (IRAS11506b; blue) and of the nucleus (IRAS11506a; green) of the IRAS11506−3851 galaxy. The wavelength calibration still needs to be applied.

we set the Gemini/GMOS PA to observe both nuclei of IRAS15587+1609 (Fig. 1). In the case of IRAS11506−385, we observed the nucleus as well as the circum-nuclear star forming regions (Fig. 1).

Fig. 2 shows spectra, in the wavelength range between roughly 4500Å and 7200Å, of IRAS15587+1609 taken from the east (IRAS15587a) and north-west (IRAS15587b) nuclei. Both spectra clearly show H_α and [NII] emission lines. An more weaker emission of [OIII]5007, [OI]6300, and [SII]6717,31, can be seen in the detected limits. Fig. 2 also shows the nuclear spectrum of IRAS11506−3851 (IRAS11506a) as well as a circum-nuclear star forming region north-West of the nucleus (IRAS11506b). The same emission lines were detected in both spectra of the IRAS11506−3751 system, but we can see a more intense H_β absorption line in the star-forming region which may indicate a young stellar population.

4. Conclusion

We measured the Hα equivalent widths(EW) and the fluxes of the Hα and [NII]6583 emission lines from the one-dimensional spectra of both the IRAS15578+1609 and IRAS11506−3851 systems, in order to construct a diagnostic diagram using $W_{H\alpha}$ versus [NII]/Hα (WHAN,(Cid Fernandes et al. 2011)). From Fig. 3 we can conclude that both nuclei of the IRAS15578+1609 system host star forming (HII) regions. On the other hand, IRAS11506−3751 hosts in its nucleus a strong AGN, whereas the circum-nuclear region seems also to be consistent with photoionization by the AGN. However more investigation need to be addressed order to compare whether this shock ionization is driven by either AGN and starburst super winds or galaxy collisions.

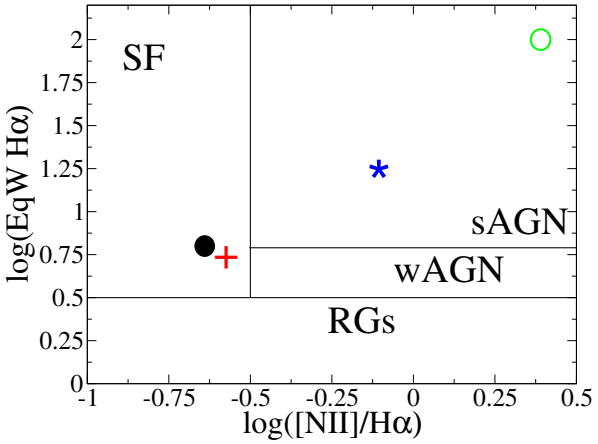

Figure 3. WHAN diagram of the IRAS15587+1609 and IRAS11506−3751 systems. IRAS15587a is represented by the black circle, while IRAS15587b, IRAS11506a and IRAS11506b are represented by a red cross, blue star and green empty circle, respectively. The SF, sAGN, wAGN and RGs are delimited regions corresponding to star-formation, weak-AGN, strong-AGNs and retired galaxies, respectively.

References

Baan, Haschick , & Henkel. 1989, ApJ, 346, 680.
Cid-Fernandes, Stasinska, Mateus, & Vale-Asari. 2011, MNRAS, 413, 1687.
Lo, K. L., 2005, ARA&A, 43, 625.
Momjian, romney, Carilli, & Troland, 2006, ApJ, 653, 1172.
Parra, Conway, Elitzur, & Pihlström, 2005, A&A, 443, 383.
Rovilos, Diamond, Lonsdale, & Smith, 2002, in Proceeding of the 6th EVN Symposium, 179.