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A panchromatic spatially resolved study of the inner 500 pc of NGC 1052

Luis G. Dahmer-Hahn[1], Rogério Riffel[2], Tiago V. Ricci[3], João E. Steiner[4], Thaisa Storchi-Bergmann[2], Rogemar A. Riffel[5,6], Roberto B. Menezes[7], Natacha Z. Dametto[8], Marlon R. Diniz[5], Juliana C. Motter[2] and Daniel Ruschel-Dutra[8]

[1]Laboratório Nacional de Astrofísica, Itajubá-MG, Brazil
email: lhahn@lna.br

[2]Departamento de Astronomia, Universidade Federal do Rio Grande do Sul

[3]Universidade Federal da Fronteira Sul, Campus Cerro Largo

[4]Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo

[5]Universidade Federal de Santa Maria, Departamento de Física

[6]Center for Astrophysical Sciences, Department of Physics and Astronomy

[7]Centro de Ciências Naturais e Humanas, Universidade Federal do ABC

[8]Departamento de Física - CFM - Universidade Federal de Santa Catarina

Abstract. We analyzed the inner $320 \times 535\,\mathrm{pc}^2$ of the elliptical galaxy NGC 1052 with integral field spectroscopy, both in the optical and in the near-infrared (NIR). The stellar population analysis revealed a dominance of old stellar populations from the optical data, and an intermediate-age ring from NIR data. When combining optical+NIR data, optical results were favoured. The emission-line analysis revealed five kinematic components, where two of them are unresolved and probably associated with the active galactic nucleus (AGN), one is associated with large-scale shocks, one with the radio jets, and the last could be explained by either a bipolar outflow, rotation in an eccentric disc or a combination of a disc and large-scale gas bubbles. Our results also indicate that the emission within the galaxy is caused by a combination of shocks and photoionization by the AGN.

Keywords. galaxies: individual: NGC 1052 - galaxies: jets - galaxies: nuclei - galaxies: elliptical and lenticular, cD

1. Introduction

A Low-ionization nuclear emission-line region (LINER, Heckman 1980) is a very well studied type of galaxy. The main conundrum behind LINERS is the fact that many mechanisms are capable of producing a low ionization spectrum, such as (i) shocks, (ii) photoionization by low luminosity active galactic nuclei, (iii) post-asymptotic giant branch stars, and (iv) starbursts dominated by Wolf-Rayet stars.

NGC 1052 is the prototypical LINER galaxy, located at a distance of 19.1 Mpc, subject of a long and intense debate surrounding its LINER emission. Whereas some authors (Koski & Osterbrock 1976; Fosbury *et al.* 1978, 1981; Dopita *et al.* 2015) suggest shocks as the main ionization source behind this galaxy, other authors found evidence of photoionization as the main driver behind its lines (Diaz *et al.* 1985; Gabel *et al.* 2000).

2. The data

In order to disentangle the various mechanisms which are capable of producing a LINER-like spectrum, we employed optical and NIR integral field specroscopy obtained with Gemini Multi-Object Spectrograph (GMOS) and Near-Infrared Integral-Field Spectrograph (NIFS), respectively. Both data sets were reduced using the standard reduction scripts distributed by the Gemini team. We also performed differential atmospheric refraction correction, Butterworth spatial filtering, and instrumental fingerprint removal. Lastly, we combined optical and NIR datacubes by slicing each NIR spaxel to 900 subspaxels (30×30) and adding their fluxes to the optical spaxel that matched the central position of the NIR subspaxel.

3. Stellar population

To study the stellar population of NGC 1052, we used the STARLIGHT code (Cid Fernandes *et al.* 2004, 2005) with E-MILES library of simple stellar populations (SSPs, Vazdekis *et al.* 2016). By fitting the optical datacube, we found only old stellar content in the entire datacube, dominated by ∼12Gyr SSPs. When fitting the NIR datacube, we found the same results in the nucleus of the galaxy, with the circumnuclear population dominated by ∼2.5 Gyr SSPs. By performing the synthesis using the panchromatic datacube, we found again a dominance of older stellar populations (∼12 Gyr). We attribute this difference between optical and NIR results to the lack of H-band data and the low signal-to-noise ratio of our J-band data.

4. Gas excitation and Kinematics

The emission-line fluxes were measured in a pure emission-line spectrum, free from the underlying stellar flux contributions. Close to the centre of our FoV, an unresolved broad component is present in Hα. Also in the nucleus, an unresolved blue wing is visible on [OIII] with $1380\,\mathrm{km\,s^{-1}}$. In order to reproduce the extended emission, two Gaussian functions were needed in order to fit each emission-line profile, one narrow ($100\,\mathrm{km\,s^{-1}} < \mathrm{FWHM} < 150\,\mathrm{km\,s^{-1}}$) and one with intermediate width (IW, $280\,\mathrm{km\,s^{-1}} < \mathrm{FWHM} < 450\,\mathrm{km\,s^{-1}}$). The narrow emission is compatible with two previously detected gas bubbles, which were attributed to large-scale shocks. The IW component, on the other hand, can be explained by an outflow, an eccentric disc, or a combination of a disc with large-scale shocks. When analysing density, temperature, and diagnostic diagrams, our results suggest that the ionization within the FoV of our data cannot be explained by one mechanism alone. Rather, our results suggest that photoionization is the dominant mechanism in the nucleus, with the extended regions being ionized by a combination of shocks and photoionization.

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