Modelling Blue Compact Dwarf Galaxies with MOCASSIN

Oskar Ł. Karczewski*, Michael J. Barlow, Mathew J. Page, Suzanne C. Madden
and the SPIRE SAG2 DGS team

*o.karczewski.09@ucl.ac.uk
Department of Physics & Astronomy, University College London, Gower Street, London, WC1E 6BT, UK

ABSTRACT

We present a photoionisation model of the blue compact dwarf galaxy NGC 4449. In our model the central ionising source is described by a synthetic stellar spectrum generated by STARBURST99 (Leitherer et al. 1999). We use MOCASSIN (Ercolano et al. 2003, 2005, 2008) to solve the radiative transfer for the coexisting gas and dust phases. The best-fit model reproduces the global optical emission line fluxes and the observed spectral energy distribution (SED) spanning wavelengths from the UV to sub-mm. Our technique, first applied by James (2009) to model Mrk 996, can be used to deduce underlying stellar components and derive spatially resolved physical characteristics of dwarf galaxies.

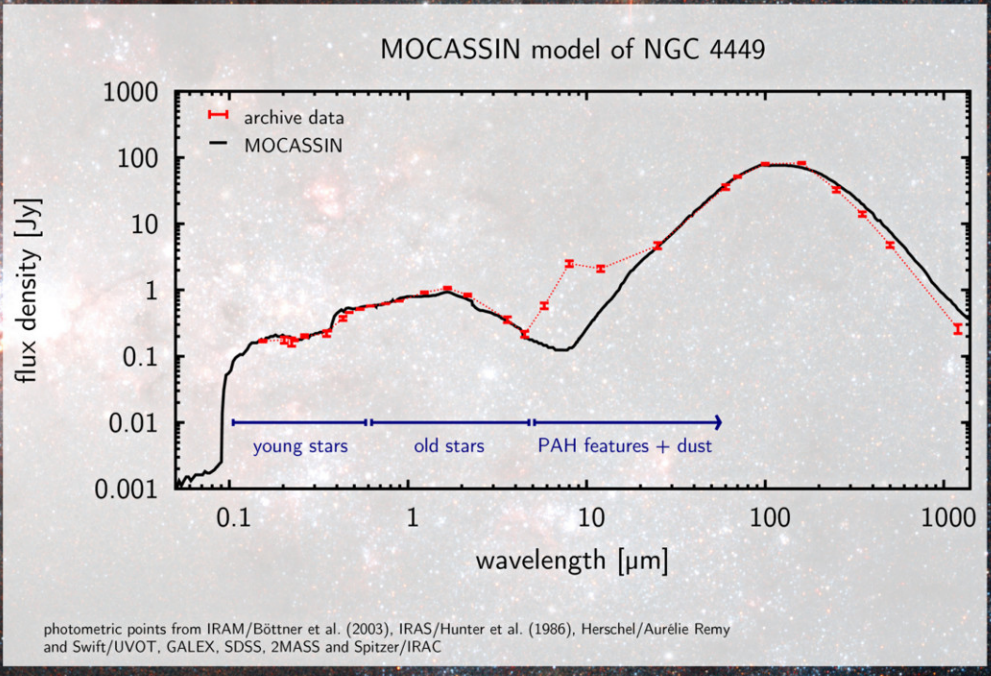
NGC 4449

Distance	4.2 Mpc	1
12+log(O/H)	8.23	2,a
R_{25}	1′.8 (2.2 kpc)	3
R_{HI}	11′.6 (14.2 kpc)	3
M_{HI}	2.0×10^9 $M_\odot$	3
M_d	2.0×10^6 $M_\odot$	2,b
$\log(L_{H\alpha})$	40.82	4

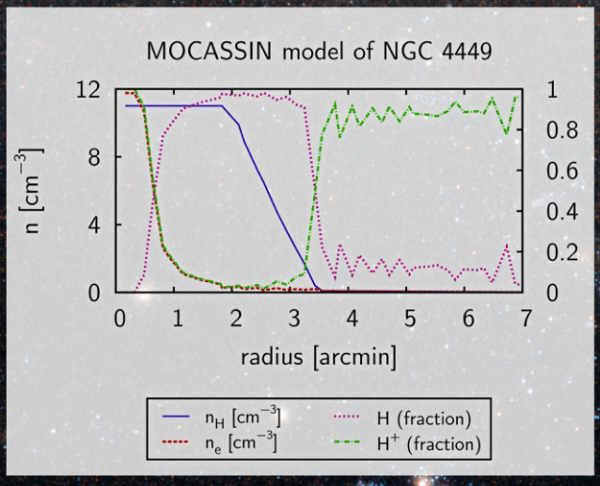
[1]Karachentsev (2005); [2]Engelbracht et al. (2008); [3]Swaters et al. (2002); [4]Hunter et al. (1999)
[a]empirical, R_{23}
[b]from the 70μm/160μm colour temperature

MOCASSIN model of NGC 4449: (P)redicted relative line intensities, (O)bserved intensities and the predicted/observed ratio (P/O).

line [Å]	P	O	P/O
3727 [O II]	2.999	3.891	0.771
3868 [Ne III]	0.151	0.189	0.800
4363 [O III]	0.015	0.017	0.883
4471 He I	0.026	0.035	0.737
4861 Hβ	1.000	1.000	1.000
4959 [O III]	0.687	0.689	0.997
5007 [O III]	2.049	2.069	0.990
5876 He I	0.071	0.079	0.895
6312 [S III]	0.014	0.019	0.728
6548 [N II]	0.083	0.115	0.724
6584 [N II]	0.254	0.338	0.753
6678 He I	0.020	0.028	0.717
6717 [S II]	1.539	0.476	3.234
6731 [S II]	1.071	0.334	3.206



photometric points from IRAM/Böttner et al. (2003), IRAS/Hunter et al. (1986), Herschel/Aurélie Remy and Swift/UVOT, GALEX, SDSS, 2MASS and Spitzer/IRAC



RESULTS & DISCUSSION

Our best-fit spherically-symmetric model is set up using 70×70×70 grid cells extending to the physical radius of 7′ (8.5 kpc) from the central ionising source and containing a distribution of 1.1 × 10^9 $M_\odot$ of gas and 6 × 10^6 $M_\odot$ of dust.

A combination of three representative stellar populations with ages 3 Myr, 100 Myr and 4 Gyr (1:200:1000 by mass) is found to give a good fit to the observed SED at the UV/optical wavelengths. The representative ages agree well with observations: the presence of young Wolf-Rayet stars was suggested by Martin & Kennicutt (1997) and, similarly, the existence of an underlying population with the mean age of 3-5 Gyr was deduced by Bothun (1986). Our model matches most of the available line intensities and line ratios (Kobulnicky et al. 1999, Lequeux et al. 1979). The dust used is 50% amorphous carbon and 50% silicates. Our model does not include PAH molecules, which are likely to account for the mid-IR excess (Spitzer IRS spectra show strong PAH emission bands).

FUTURE WORK

MOCASSIN has been used with success to produce a 3D model of the planetary nebula NGC 6302 (Wright et al. 2011). Our aim is to apply these modelling techniques, together with the new spatially resolved measurements being acquired with Herschel/PACS integral field unit (IFU), to develop the first fully three-dimensional detailed MOCASSIN model of an entire dwarf galaxy.

References:
Bothun, G. D. 1986, AJ, 91, 507
Böttner, C., et al. 2003, A&A, 408, 493
Engelbracht, C. W., et al. 2008, ApJ, 678, 804
Ercolano, B., et al. 2003, MNRAS, 340, 1136
Ercolano, B., et al. 2005, MNRAS, 362, 1038
Ercolano, B., et al. 2008, ApJS, 175, 534
Hunter, D. A., et al. 1986, ApJ, 303, 171
Hunter, D. A., et al. 1999, ApJ, 118, 2184
James, B. L. 2009, PhD Thesis, UCL
Karachentsev, I. D. 2005, AJ, 129, 178
Kobulnicky, H. A., et al. 1999, ApJ, 514, 544
Leitherer, C., et al. 1999, ApJS, 123, 3
Lequeux, J., et al. 1979, A&A, 80, 155
Martin, C. L., & Kennicutt, R. C. 1997, ApJ, 483, 69
Swaters, R. A., et al. 2002, A&A, 390, 829
Wright, N. J., et al. 2011, MNRAS, submitted

NGC 4449

Image Credit: NASA, ESA, A. Aloisi (STScI/ESA), and The Hubble Heritage (STScI/AURA)-ESA/Hubble Collaboration