A Multi-wavelength MOCASSIN Model of NGC 4449

O. Ł. Karczewski*, M. J. Barlow, M. J. Page, S. C. Madden
and the SPIRE SAG2 DGS team

*olk@star.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 matching 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 can be used to deduce underlying stellar components and derive spatially resolved physical characteristics of dwarf galaxies.

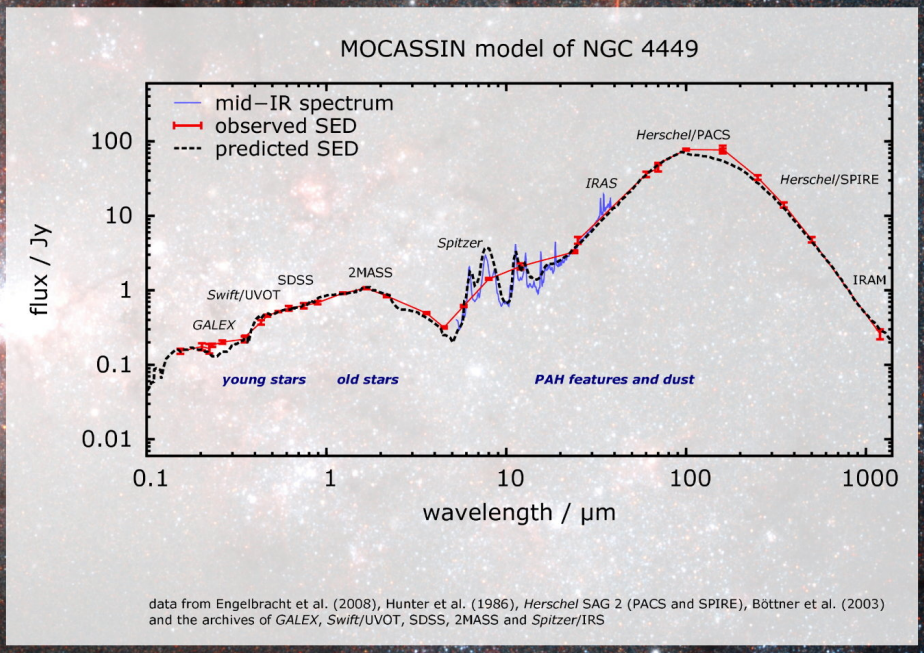
NGC 4449

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

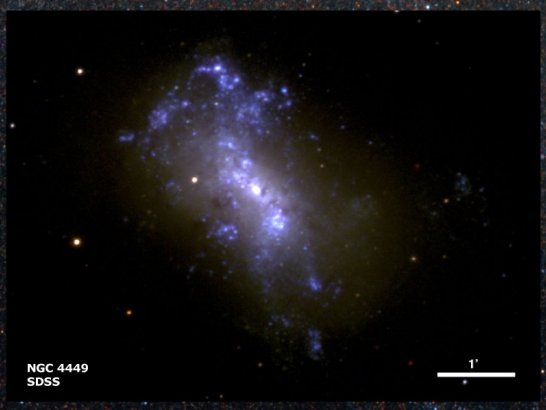
[1]Karachentsev (2005); [2]Engelbracht et al. (2008); [3]Swaters et al. (2002); [4]Hunter et al. (1999)
[a]empirical, R_{23}
[b]from the 70μm/160μm colour temperature

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]	2.852	3.891	0.733
3868 [Ne III]	0.182	0.189	0.961
4861 Hβ	1.000	1.000	1.000
4959 [O III]	0.752	0.689	1.091
5007 [O III]	2.244	2.069	1.085
5876 He I	0.082	0.079	1.037
6312 [S III]	0.011	0.019	0.587
6548 [N II]	0.092	0.115	0.799
6584 [N II]	0.281	0.338	0.831
6678 He I	0.023	0.028	0.828
6717 [S II]	1.572	0.476	3.303
6731 [S II]	1.102	0.334	3.299



data from Engelbracht et al. (2008), Hunter et al. (1986), *Herschel* SAG 2 (PACS and SPIRE), Böttner et al. (2003) and the archives of *GALEX*, *Swift*/UVOT, SDSS, 2MASS and *Spitzer*/IRS



RESULTS & DISCUSSION

Our MOCASSIN model matches the observed SED of NGC 4449 and most of the available global emission line intensities (Kobulnicky et al. 1999).

The best matching spherically-symmetric model was set up using 80×80×80 grid cells extending to the physical radius of 2′.7 (3.3 kpc) from the central ionising source and containing a distribution of 1.5×10^9 $M_\odot$ of gas and 2.3×10^6 $M_\odot$ of dust.

Two continuous episodes of star formation were assumed. The best matching model requires continuous star formation over the last 6 Gyr, and the ranges of 6 Gyr to 120 Myr (SFR of 0.2–0.3 $M_\odot$ yr^{-1}) and 120 Myr to present (SFR of 0.06–0.12 $M_\odot$ yr^{-1}) for the two episodes. The dust composition used in this model was 95% amorphous carbon and 5% PAHs following the description of Draine & Li (2007). These results agree with observations: Annibali et al. (2008) deduce continuous star formation activity over the last Gyr from resolved stellar population studies, the presence of young Wolf-Rayet stars was suggested by Martin & Kennicutt (1997) and the existence of an underlying population with the mean age of 3–5 Gyr was deduced by Bothun (1986).

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 *Spitzer*/IRS maps and the new spatially resolved measurements acquired with *Herschel*/PACS integral field unit (IFU), to develop the first fully three-dimensional MOCASSIN model of an entire dwarf galaxy.

References:
Annibali, F., et al. 2008, AJ, 135, 1900
Bothun, G. D. 1986, AJ, 91, 507
Böttner, C., et al. 2003, A&A, 408, 493
Draine, B. T. & Li, A. 2007, ApJ, 657, 810
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. 1986, ApJ, 303, 171
Hunter, D. A., et al. 1999, ApJ, 118, 2184
Karachentsev, I. D. 2005, AJ, 129, 178
Kobulnicky, H. A., et al. 1999, ApJ, 514, 544
Leitherer, C., et al. 1999, ApJS, 123, 3
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, 418, 370

NGC 4449

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