Spectral energy distribution of Mrk 509

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Introduction

The main challenge is that nearly all observational tracers used to estimate star formation (SF) parameters in galaxies suffer from severe contamination by emission from the active galactic nucleus (AGN) itself, especially for type 1 nuclei.

Mrk 509 is a Seyfert 1 nucleus/quasar hosted by an S0 galaxy with a star-forming circumnuclear ring but still shows no evidence of non-axisymmetric perturbation of the potential (Slavcheva-Mihova & Mihov 2011). We found that the galaxy to the north-northwest is a physical companion (Slavcheva-Mihova & Mihov 2012).

Aims and methods

We address the issue of disentangling the contribution of the AGN and host galaxy of Mrk 509 in the circumnuclear region by fitting its spectral energy distribution (SED). Our approach is twofold: 1) We compile the FIR-to-UV SED using the available sky surveys. The SED is fitted with the AGNfitter code implementing a Bayesian MCMC approach. It accounts for the emission of the accretion disk (AD), torus, host galaxy stellar population (SP), and cold dust related to the SF regions. 2) A 2-D decomposition of the circumnuclear galaxy region is performed using GALFIT. We model the AGN, bulge, disk, and ring. Two sets of SEDs are then constructed - (i) of the host galaxy (the total flux with the AGN flux subtracted) and (ii) of the ring.

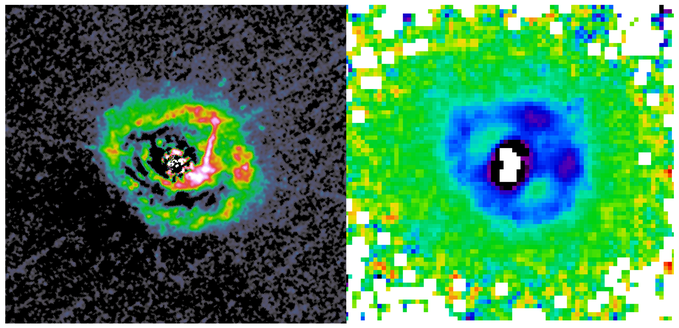

Fig. 1

Fig. 2

Results and Discussion

Fig. 1 reveals the 2-D decomposition residual HST image with the models of the AGN, bulge, and disk subtracted. The ring with the SF regions is outlined, together with a straight feature pointing to north-northwest. The ring appears blue on the CFHT colour index image (Fig. 2).

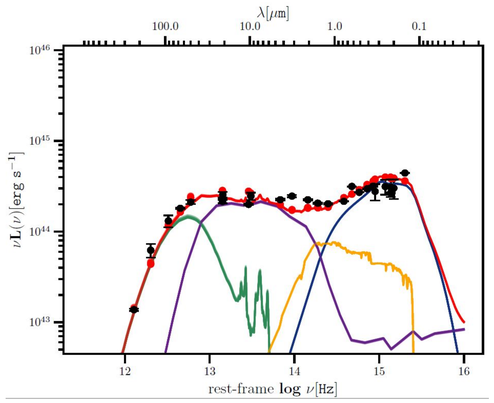

Fig. 3

The total SED of Mrk 509 is shown in Fig. 3. As the AGN outshines the host galaxy, the AD emission can be well constrained, while this does not hold true for the galaxy SP. That is why we constructed the NIR-to-optical SED of the host galaxy (the total flux with the AGN flux subtracted) and fitted it with an SP model (Fig. 4). Then we fitted the FIR-to-UV SED of Mrk 509 with the models related both to the AGN and the host galaxy, keeping the SP component roughly fixed to the above model (Fig. 4). The output AGN parameters: dereddened luminosity L_{BBB} and extinction $E(B\text{-}V)_{BBB}$ of the AD, as well as column density N_H and luminosity L_{tor} of the torus, are listed in Table 1. Generally, the parameters related to the host galaxy are not reliable. However, the SFR in the FIR, SFR_{IR} can be considered a reasonable estimate.

We constructed a NIR-to-optical SED of the ring and fitted it with an SP model. Table 2 lists the output parameters: the stellar mass, M_{SP}, luminosity, L_{gal}, extinction, $E(B\text{-}B)_{gal}$, SF history timescale, τ, and age, as well as SFR in the optical/UV $SFR_{opt/UV}$ in the ring. The timescale and age are consistent with young SP. We derive $SFR_{opt/UV}$ = 6.7 $M_\odot$ yr^{-1}. There are no SFR estimates using SED fitting for this object up to our knowledge.

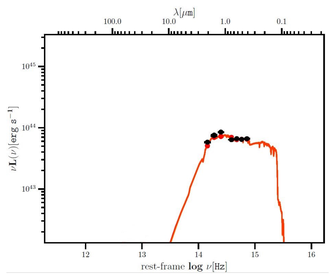

Fig. 4

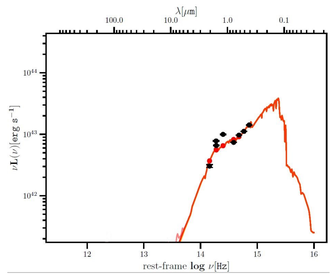

Fig. 5

The reported rates based on the [Ne II] line are 8.36 $M_\odot$ yr^{-1} within an aperture diameter D = 3.37 kpc (Meleendez et al. 2008) and 8 $M_\odot$ yr^{-1} for D ≈ 4 kpc (Diamond-Stanic & Rieke 2012). The latter authors found 4.7 $M_\odot$ yr-1 in D ≈ 4 kpc for the 11.3 μm aromatic feature. Thus, our SFR estimate in the optical is in agreement with the above values. Furthermore, as the SB component dominates the FIR region, the SFR in the FIR, SFR_{IR} = 8.89 $M_\odot$ yr^{-1} can be considered an independent estimate (and an upper limit as it was derived based on the host galaxy SED). Both estimates based on SED fitting are in good agreement.

Log (N_H)	$E(B\text{-}V)_{BBB}$	L_{BBB}(0.1-1 μm)	L_{tor}(1-30 μm)
Log (cm^{-2})	mag	Log ($L_\odot$)	Log ($L_\odot$)
21.25	0.05	44.95	44.72

τ	Log (age)	$E(B\text{-}V)_{gal}$	Log (M_{SP})	L_{gal}(0.1-1 μm)	$SFR_{opt/UV}$	SFR_{IR}
Gyr	Log (yr)	mag	Log ($M_\odot$)	Log ($L_\odot$)	$M_\odot$ yr^{-1}	$M_\odot$ yr^{-1}
0.08	7.30	0.15	8.11	43.62	6.70	8.89

Tables 1,2 (see text)

References

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