Dust and Star Formation in the Tidal Dwarf Galaxy in Arp 245

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Summary

Arp 245 is an interacting system, containing a Tidal Dwarf Galaxy (TDG), Arp245N, in the northern tidal tail. We measured the spectral energy distribution (SED) of the dust emission from Spitzer and Herschel data for this object and for a region in the tidal tail, and fitted it with a dust model (Galliano et al. 2011). We derive very similar dust SEDs for both the TDG and the tidal tail, both with a low temperature (T~16K), suggesting that cool dust, possibly situated in the tail and seen in projection, is dominating over that from the star forming region in the TDG. We calculate the dust mass, and derive, together with the H_2 and HI mass from the literature, a gas-to-dust mass ratio of 330 for the TDG. Finally, we measure the star formation rate (SFR) in the TDG from the 24 μm and Hα emission. We compare its star formation efficiency (SFE) and the star formation (SF) law to that of a sample of spiral galaxies, and find good agreement, indicating that SF proceeds in a similar way in TDGs.

Dust and gas in Arp 245

Arp245 is a nearby system, consisting of two interacting spiral galaxies and a TDG, Arp245N (see Fig. 1 for an optical image). Due to its proximity, it is one of the few cases where the TDG can be spatially resolved in the far-infrared.

The system is HI rich, with HI following the tidal tails and peaking at the position of Arp245N (see Fig. 2, and, for higher-resolution HI data Fig. 3). Arp245N has been mapped in CO all along its extension and at a position in the tail with the IRAM 30m telescope (Braine et al. 2001). Furthermore, it has been observed with OVRO with CO being detected close to the SF region (see Fig. 6, Brinks, Walter & Duc 2004).

The object has been observed with Spitzer (IRAC and MIPS) and with Herschel (PACS and SPIRE), probing the full dust SED. Fig. 3 shows some of these maps (8, 100, 160 and 250 μm), overlaid with high-resolution HI contours.

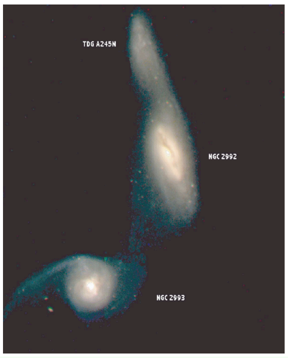

Fig. 1: Optical true colour image (BVR bands), showing the system (from Duc et al. 2000) .

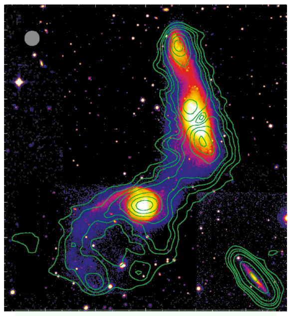

Fig. 2: V-band image with HI contours from VLA CS arrys observations (from Duc et al. 2000)

Tab. 1: General properties of the TDG Arp 245N

Distance	31 Mpc	
Metallicity	12+log(O/H)=8.6±0.2	Duc et al. (2000)
M_{mol} (OVRO)	4.8 10^7 Mo	Brinks et al. (2004)
M_{mol} (IRAM30m)	2 10^8 Mo	Braine et al. (2001)
M_{HI}	1.2 10^9 MO	This work
M_{dust}	4.2 10^6 Mo	This work
M_{gas}/M_{dust}	330	This work
SFR	0.04 Mo yr^{-1}	This work
log(SFE)	0.9 Gyr^{-1}	This work

The molecular gas mass was caclulated adopting $N(H_2)/I_{CO} = 2\ 10^{20}\ cm^{-2}/(K\ kms^{-1})$
The gas masses include a helium fraction of 1.36.

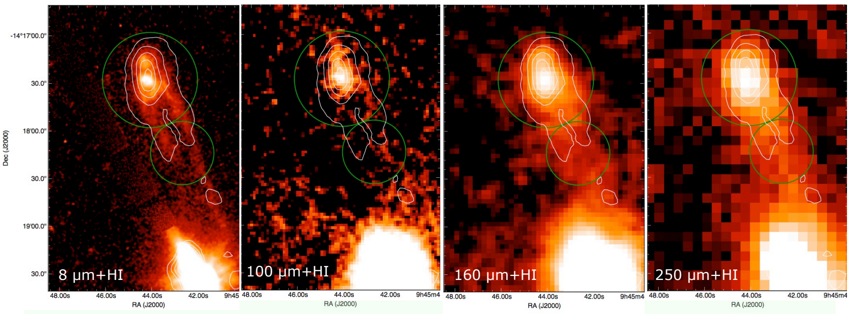

Fig. 3: The dust emission at 8, 100, 160 and 250 μm, overlaid with B+C VLA HI observations. The green circles show the apertures used for the photometry of the TDG and the tidal tail. The HI contours levels are at (1.2, 4, 7.5, 10, 14) x 10^{21} cm^{-2}.

The dust SED and M_{gas}/M_{dust}

We smoothed all images to a common resolution equal to that of the Spire 500 μm band, using the kernels of Aniano et al. (2011). Then, we performed aperture photometry for the TDG and a region in the tail, using the regions indicated in Fig. 3.

The resulting SEDs have similar shapes for both regions. We fitted them with the model of Galliano et al. (2011) (Fig. 4). The dust emission was found to be cold (Teq = 15-16 K) in both regions. This suggests that the TDG is dominated by cool dust, most likely from the tail which is seen in projection (Brinks, Walter & Duc 2004). The gas-to-dust mass ratio for the TDG is 330, about a factor 2 above the Galactic value (see Tab. 1 for dust and gas masses) in spite of the similar metallicity.

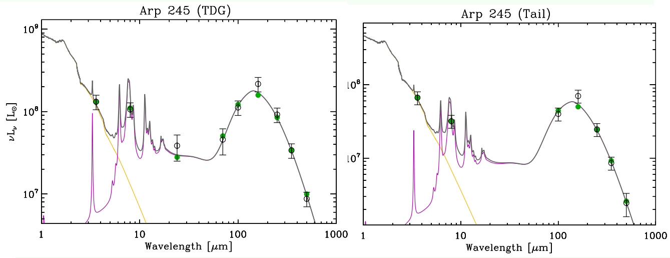

Fig. 4: Fit to the dust SED from the TDG (large aperture in Fig. 3) and the tail (small aperture in Fig. 3) with the model of Galliano et al. (2011). The yellow line denotes the stellar and the magenta line the dust emission.

The star formation law in a TDG

Our observations allow to study the SF law in a TDG at a high resolution (see the distribution of SF and gas tracers in Fig. 5). We derived the SFR from a combination of the 24 μm and Hα emission (from Duc et al. 2000) as:

SFR(Hα+24μm)(Mo yr-1) = 5.45 10-42[L(Hα)+0.020L(24μm)](Kennicutt et al. 2009).

We calculate the SF efficiency as SFE = SFR/Mmol from the molecular gas mass observed with the interferometer OVRO. These observations are adequate because they filter out the smoothly distributed molecular gas emission that is most likely associated with the tail and not with the TDG. We derive a value of log(SFE) = -9.1,which lies within the range found by Bigiel et al. (2011) within disks of nearby galaxies (log(SFE) = -9.23±0.23). Fig. 6 shows that Arp 245N follows the SF law found for this sample. This is in agreement with the result for the TDG in Arp 158 (Boquien et al. 2011).

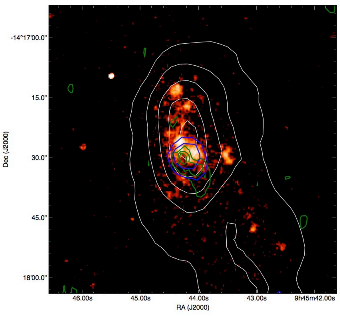

Fig. 5: An overlay of SF and gas tracers in Arp 245N (Color image: Hα, magenta contours: 24μm : green contours: CO from OVRO, white contours: HI

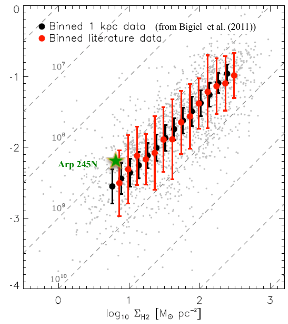

Fig. 6: The SF law derived for a sample of spiral galaxies, both from spatially resolved and from global data (Bigiel et al. 2011). The star denotes the position of the TDG Arp 245N.