The star formation law in Tidal Dwarf Galaxies


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Summary

Tidal Dwarf Galaxies (TDGs), formed from recycled gas in galaxy interactions, have in general similar properties as ordinary dwarf galaxies. One important difference is their higher (close to solar) metallicity since they are made from recycled gas. This property makes CO a good tracer for the molecular gas content. This allows us to directly study the relation between the star formation (SF) and the molecular gas in this special environment which is characterized by a lack of spiral density waves and the presence of tidal forces. We can summarize our results from a sample of 14 TDGs with single dish and interferometric CO data:

- We generally find a close relation between the star formation rate (SFR) per area and the molecular gas mass surface density (the Kennicutt-Schmidt law) consistent with that found in spiral galaxies. There are, however, two notable exceptions from this relation:
  - We find in some cases abundant quantities of molecular gas which are not associated to any star formation. The line width of this component is generally broader than that of the star-forming molecular gas.
  - In one object (VCC 2062) we find a clear deviations from the SF law with a considerably lower star formation efficiency (SFE=SFR/M(H2)). This could either be due to a genuinely local low star formation efficiency or due the presence of close-by molecular gas which is not associated to the star formation.

Molecular gas in TDGs

We have observed the CO(1-0) emission of a sample of 14 TDG, both with single dish (IRAM 30m telescope) and with interferometric instruments (IRAM Plateau de Bure/OVRO). The general conclusions from these spectra (see examples) are:

- There is generally good spatial and kinematical agreement between the CO and the HI spectra.
- CO is found where SF takes place.
- CO is sometimes found abundantly outside SF region. The line-width of the molecular gas outside SF regions is usually broader.

The SF law in TDGs

Below we show the surface density of the molecular gas vs the SFR per area for our sample of TDGs. The SFR was estimated mostly from Hα, but also from UV and 8 µm. We compare this relation to the SF law found for spiral galaxies. We conclude:

- Most objects follow the general SF law for spiral galaxies.
- There is one clear outlier (VCC 2062). Its low SFR is a robust result since different tracers (UV, Hα and 8µm) give consistent results. This can either be due to a genuine inefficient star formation (e.g. due to diffuse molecular gas without dense cores traced by CO) or due to the presence of close-by molecular gas which is not related to the observed SF.

Example 1: Arp 245N, a “classical” TDG

Arp 245 is an interacting system of two galaxies with two tidal tails. At the end of the northern tidal tail a TDG has formed. Single dish observations show that CO is distributed along the entire object whereas OVRO interferometric observation show molecular clouds that are directly coinciding with the SF region.

Example 2: VCC 2062, an old TDG in the Virgo cluster

VCC 2062 is a dwarf galaxy close to NGC4694, a perturbed early-type galaxy, connected to it by a huge HI tail. An ample data set allows us to study the SF and molecular gas in spectacular detail in this object.

The SF law derived from all the available CO data. Red data points are from interferometric data and blue data points from single dish data. The full line shows the (linear) SF law derived from Bigiel (2008, 2011) for spiral galaxies, corresponding to a star formation efficiency log(SFR/M(H2)) = -9.2 , and the dashed line the standard deviation of 0.23 dex.