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The reliability of [CII] as a SFR indicator

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Abstract: The [CII] line is an important coolant of the neutral and ionized interstellar gas. Since [CII] is the brightest line in most star-forming galaxies (owing for 0.1-1% of the FIR emission), it is a potentially powerful tracer of the star formation activity. Although [CII] predominantly cools the neutral gas in Photo Dissociation Regions (PDRs), a significant fraction of the [CII] emission can arise from the diffuse ISM (cold neutral + warm ionized), HII regions and quiescent molecular clouds.
Boselli et al. (2002) calibrated the SFR against $L_{[CII]}$ based on Hα data for 22 normal, late-type galaxies ($10^8 \leq L_{TIR} \leq 10^{10.5} L_\odot$), but found a large scatter (factor ~10). We benefit from other reliable SFR indicators (FUV, 24μm) to deduce an improved SFR and extend it to more IR-luminous objects (up to L_{TIR} ~$10^{11.8} L_\odot$).
We find that $L_{[CII]}$ and the SFR are tightly correlated. This dependence implies a more or less constant contribution to the [CII] emission from PDRs, which stems from the immediate surroundings of actively star forming regions, namely the outer layers of these photon-dominated molecular clouds, which are at the boundary of HII regions.

1. **Sample selection:** We select all 39 galaxies with available GALEX FUV and MIPS 24μm data from the unresolved galaxies sample in Brauher et al. (2008), who assembled all [CII] data from the ISO archive.

2. **Spectral classification:** Verifying that the star forming regions are the dominant contributor to the IR emission, we made a distinction based on their spectral classification. Since the AGN in Seyfert galaxies significantly contributes to the 24μm emission, while LINERS seem to be more SF dominated (see Fig.1), we will calibrate the SFR relation on the combined HII/starburst + LINER sample (24 gal's).

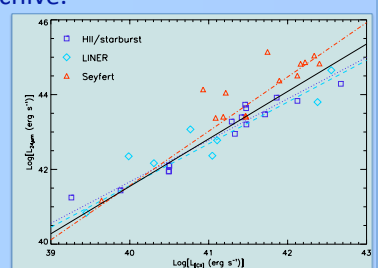

Figure 1

3. **Reference SFR tracer** From three different combinations of SFR tracers (24μm, FUV+TIR, FUV+24μm), we found the tightest relation (= smallest dispersion around the mean trend) between $L_{[CII]}$ and the SFR, when estimated from both FUV and TIR data. First, the FUV data were corrected for attenuation (Buat et al. 2005):

$$A_{FUV} = -0.0333y^3 + 0.3522y^2 + 1.1960y + 0.4967 \qquad y = \log(L_{TIR}/L_{FUV})$$

Secondly, the SFR is estimated from the extinction-corrected FUV luminosity (Kennicutt et al.2009):

$$SFR = 0.88 \times 10^{-28} L_{FUV} [\text{erg s}^{-1}\ \text{Hz}^{-1}]$$

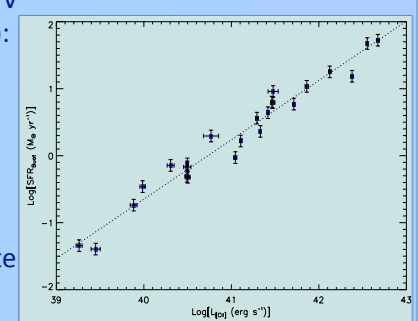
Figure 2

4. **SFR relation** We find that $L_{[CII]}$ and the SFR are tightly correlated with a 1σ dispersion of (-0.16,+0.16) dex. From the best fitting trend in Figure 2, we calibrate the SFR as:

$$SFR[M_\odot\ yr^{-1}] = 8.032e\text{-}37 \times (L_{[CII]}\ [\text{erg s}^{-1}])^{0.886}$$

5. Implications

- If the increase in the $L_{[CII]}$-to-L_{FIR} ratio with at least one order of magnitude proves valid (Maiolino et al. 2009), our SFR relation will have great implications for probing the ISM and the star formation activity in future observations of high-redshift objects with ALMA.
- The tight correlation between $L_{[CII]}$ and the SFR implies a more or less constant contribution from star-forming regions to the [CII] emission. Since the contribution from HII regions is often negligible on galactic scales, we claim a more or less constant contribution from PDRs to the [CII] emission and believe that this [CII] emission from PDRs stems from the immediate surroundings of actively star forming regions, namely the outer layers of photon-dominated molecular clumps, which are at the boundary of HII regions.