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Star formation in low-metallicity dwarf starbursts

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Introduction

First *ISO* and more recently *Spitzer* and *Herschel* have dispelled the idea that dust is absent in star formation in low-metallicity environments. While some metal-poor dwarf galaxies in the Local Universe are not particularly dusty, others show significant amounts of dust emission, usually associated with high star-formation rates. This presentation investigates the reasons behind this "dichotomy" and proposes that metallicity is not the only driver of star-formation properties either in the Local Universe, or at high redshift.

1.Method

We have obtained *Spitzer* IRAC, IRS and MIPS observations of the sample of (local) metal-poor BCDs (7.4 < 12+log O/H < 8.3) described by Hunt et al. (2010) (see Fig. 1). These data have been combined with optical+UV data from literature to assemble spectral energy distributions (SEDs), which were then fit with a vast library (~10^5) of DUSTY models (Ivezic & Elitzur, 1997).

2.Results

These low-metallicity BCDs show variations in SED shapes and IR luminosity that are decoupled from metal abundance. Figure 2 compares the SEDs of several pairs of BCDs, with similar O/H, but with rather different star-formation rates (SFRs) and SED shapes. Some BCDs show high luminosity, warmer dust and higher SFRs even at the same O/H as other BCDs which are much more quiescent (low L_{IR}, low SFR, cool dust).

Metallicity cannot be the main driver of star formation properties in (metal-poor) galaxies.

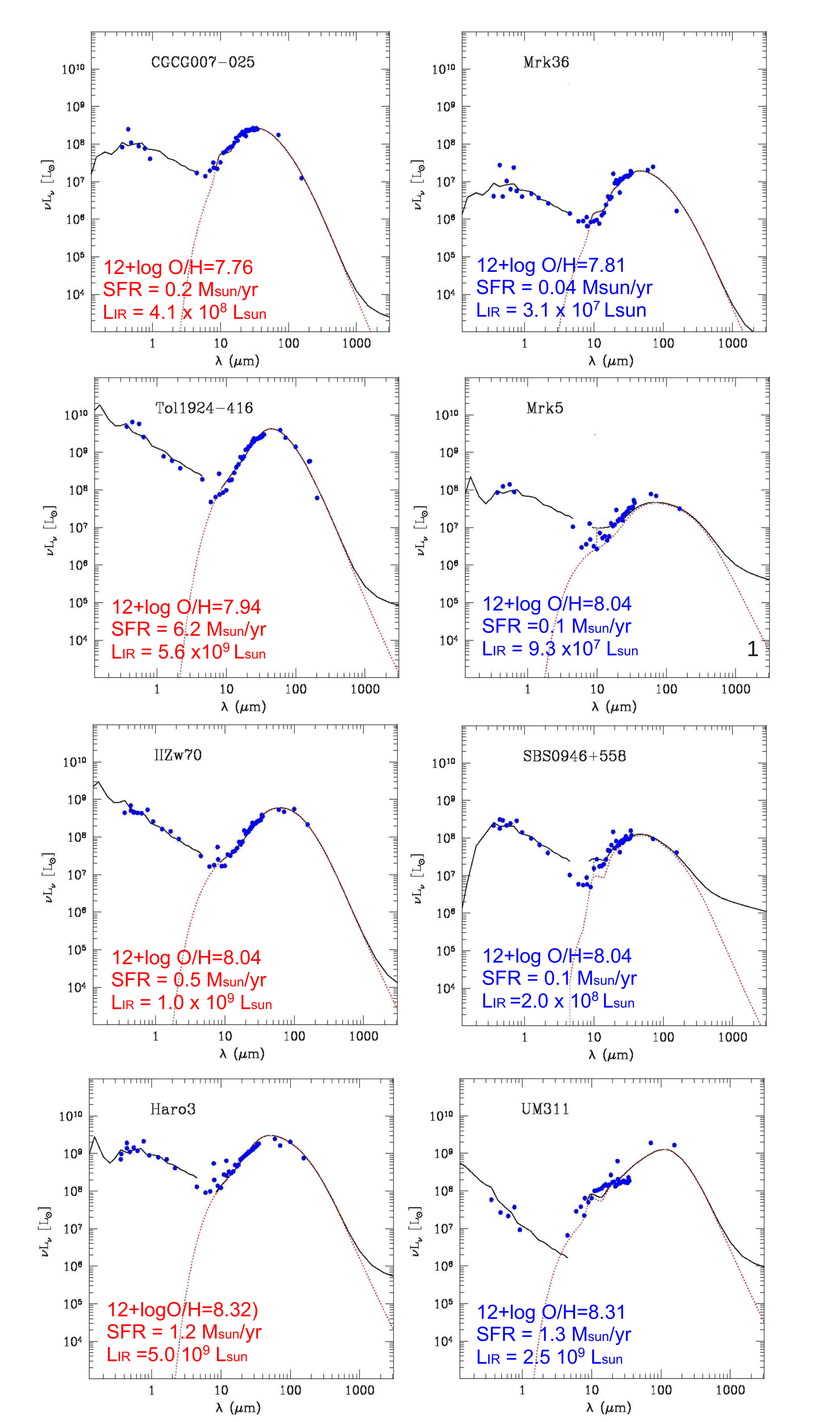

Figure 2: SEDs of matched pairs of BCDs with similar O/H (with DUSTY fits) illustrating the ACTIVE/PASSIVE dichotomy.

This "dichotomy" can also be seen in the two lowest metallicity BCDs in the local Universe, I Zw 18 and SBS 0335-052: 12+log O/H ~ 7.2. Figure 3 illustrates the SEDs of these two objects; L_{IR} in SBS 0335-052 is almost 40 times higher than in I Zw 18, and the corresponding SFRs differ by a factor of 10 or more. These BCDs are considered prototypes of what has been dubbed the "active/passive" dichotomy of SF regions.

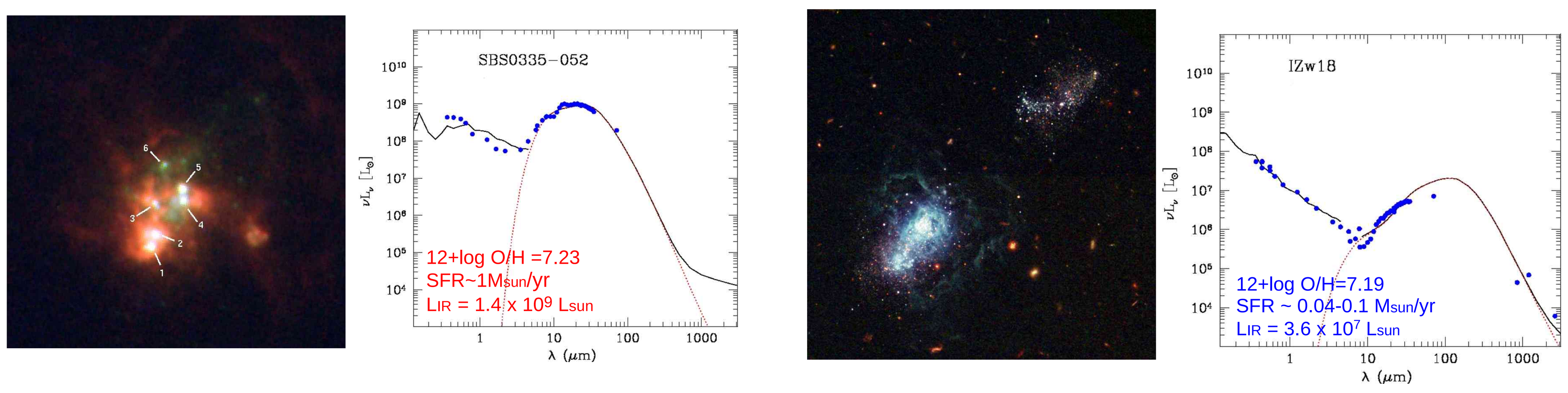

Figure 3: Two extremely metal-poor ACTIVE/PASSIVE prototypes: SBS 0335-052 (active) and I Zw 18 (passive). Left panel: ACS composite (Reines et al. 2008) with SSCs marked. SED contains data from Houck et al. (2004), Hunt et al. (2005), Reines et al. (2008). Right panel: ACS composite from Izotov & Thuan (2004). SED contains data from Wu et al. (2007), Hunt et al. (2003), Herrera Camus et al. (2010).

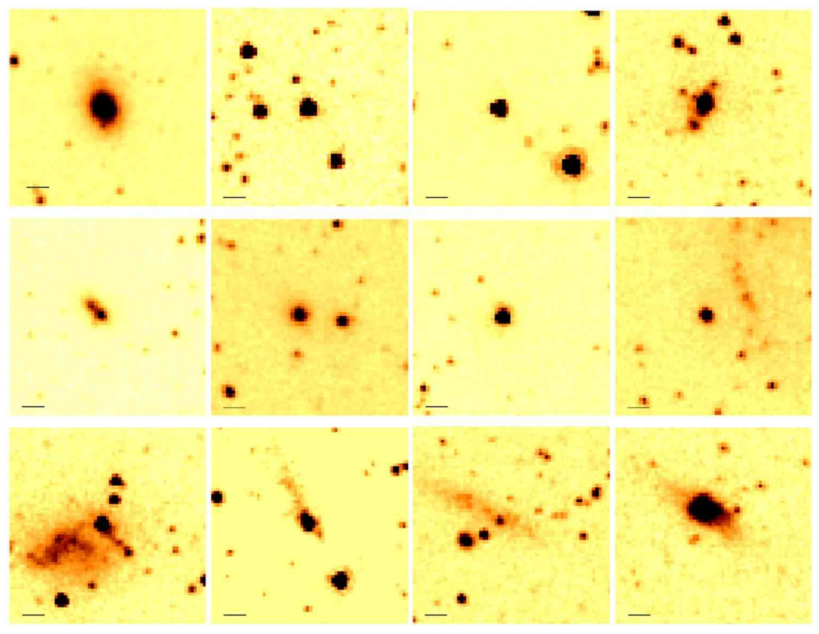

Figure 1: Spitzer/IRAC 4.5 μm images of representative BCDs (Hunt et al. 2010)

References

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3.Interpretation

Models show that for a given gas and stellar mass, smaller denser HII regions are more IR luminous than larger more diffuse ones (essentially a question of evolutionary time scale and SFR) (Hirashita & Hunt 2004, 2006). The predictions of simple models for HII regions are shown in Fig. 4, which compares the two BCD prototypes.

Physically smaller HII regions have warmer dust temperatures (see Dopita et al. 2006; Groves et al. 2008), as shown in Fig. 5. In fact, in Galactic and extragalactic HII regions, size and density are inversely correlated with approximately unit slope (see Hunt & Hirashita, 2009).

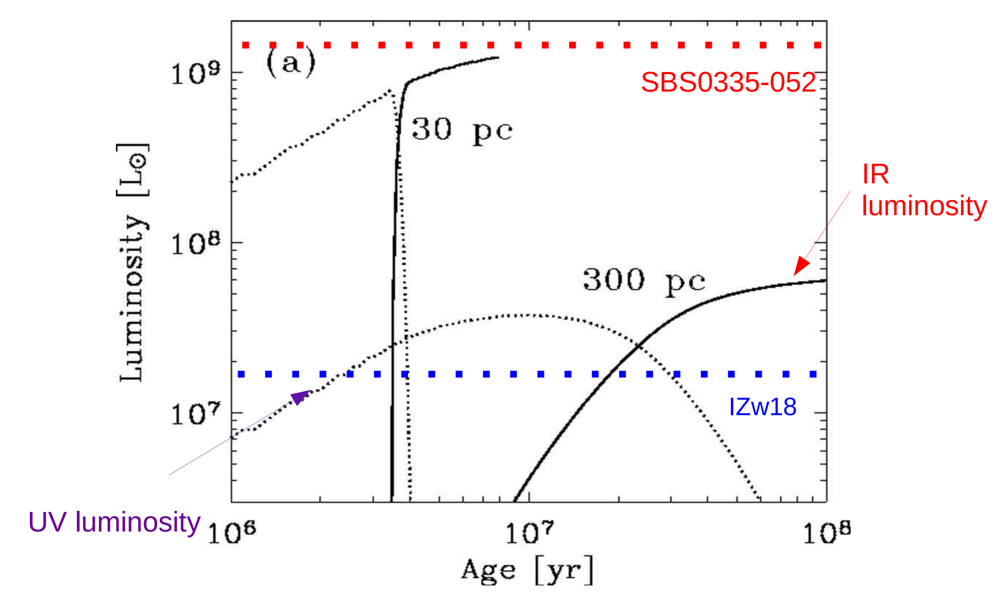

Figure 4: Time evolution of UV and IR luminosity for regions of differing sizes (taken from Hirashita & Hunt 2004). The total IR luminosities were measured with *Spitzer* (after the models were published).

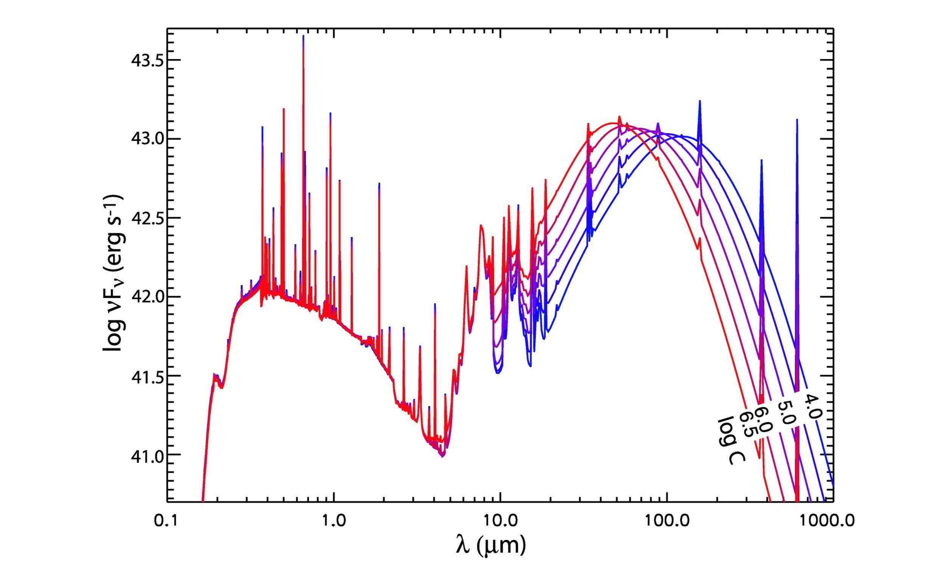

Figure 5: SEDs of solar-metallicity HII regions with varying degrees of compactness (taken from Groves et al. 2008).

The bottom line

1. Local sample of low-metallicity BCDs show variations in SED shapes and IR luminosity that are decoupled from changes in metal abundance.
2. Simple models suggest that the variations in the IR SED are due to variations in the **size and density** of the HII regions responsible for heating the dust, independently of the metallicity.
3. Compact and dense conditions in HII regions give rise to a high ionization parameter, high Σ_{SFR} and SSFR which are observed locally in "active BCDs" and in some high redshift populations.
4. Perhaps size and density are as (more?) important as metallicity in shaping galaxy evolution.