Star formation, dust, and gas properties of $z \approx 2\text{-}3$ lensed galaxies

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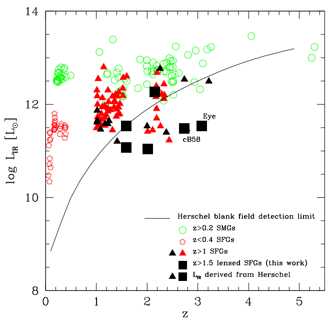
We used the *Herschel Lensing Survey* (HLS) to select and study the stellar, molecular, and dust content of highly magnified high-redshift galaxies. The observations are based on HST, ground-based, Spitzer, Herschel, SCUBA2 and IRAM. Our selected galaxies are all bright in *Herschel* due to their high magnification (μ = 3-49), but their intrinsic luminosity is in the LIRG regime ($L_{IR} < 10^{12}$ $L_{\odot}$). They are, thus, representative of typical L★ star-forming galaxies (SFGs) at z≈2. We here present an overview of their properties, in particular their dust content/properties and quantities related to their molecular gas content.

→ See also posters by Sklias et al., Zamojski et al. discussing the same HLS objects.
→ See Sklias et al. (2013, arXiv:1310.2655) and Dessauges-Zavadsky et al. (2013, to be submitted to A&A)

GALAXY PROPERTIES: LENSED SAMPLE VERSUS OTHERS



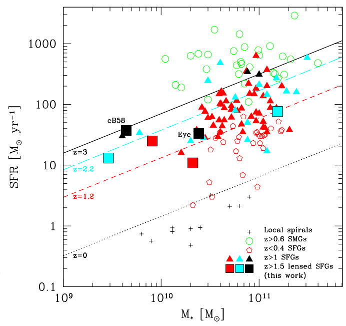
LEFT: IR luminonities (L_{IR}) of our lensed galaxies (black squares) and other comparison samples for which CO data are also available (z<0.4 SFGs from Geach et al. 2009, 2011, Bauermeister et al. 2013: open pentagons; z>1 SFGs from Daddi et al. 2010, Magnelli et al. 2012, Tacconi et al. 2013, Saintonge et al. 2013: red triangles; SMGs from numerous papers: green circles)

→ **Our sources extend well below the Herschel 3σ blank field limit (black solid line) thanks to gravitational lensing, reaching intrinsic L_{IR} < 4x10^{11} $L_{\odot}$ at z>1.5**

RIGHT: SFR-M* distribution and main-sequence best-fits at z=0, 1.2, 2.2, and 3

→ **Our sources extend by up to one order of magnitude the stellar masses of other galaxies with CO data available, reaching M_* < 2.5x10^{10} $M_{\odot}$ at z>1.5**

We have added to our sample of HLS-selected sources, the well-known strongly-lensed MS 1512-cB58 and Cosmic Eye galaxies, which we have carefully reanalysed using the latest Herschel photometry.



References

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- Bouché, N., et al. 2010, ApJ, 718, 1001
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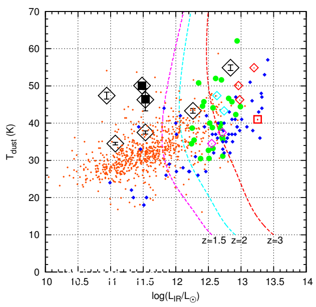
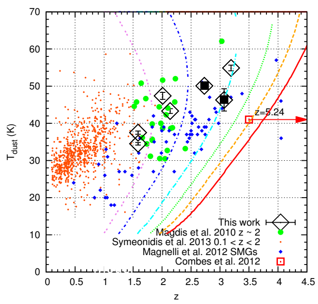
DUST PROPERTIES





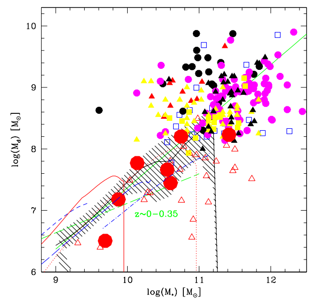
LEFT: Dust temperature versus IR luminosity and redshift comparing our lensed galaxies (diamonds) to other samples with Herschel photometry

→ **Existence of hot sources (T~45-50 K) at relatively low luminosity**

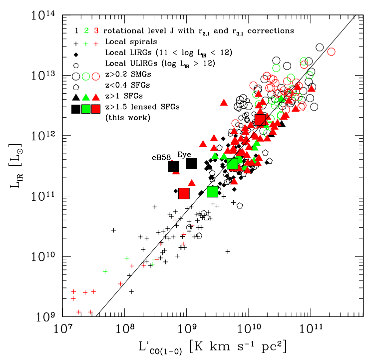
→ **Possible trend of increasing dust temperature toward higher redshifts (due to higher star formation effiiciencies, i.e. stronger radiation fields per unit gas or dust mass at high z; see Magdis et al. 2012)**

RIGHT: Dust mass versus stellar mass

→ **Our sources (red circles) which extend current measurements to lower stellar masses allow for the first time to test that dust/stellar masses are in good agreement with semi-analytical model predictions of Lagos et al. (2012; shaded area) and comparable to low-z galaxies**



GAS PROPERTIES



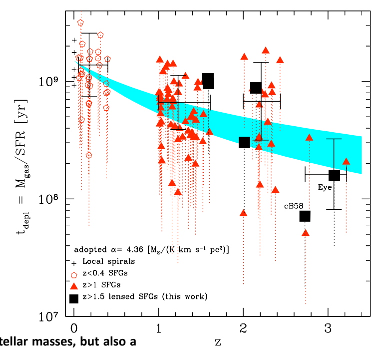
LEFT: IR luminosity versus CO(1-0) luminosity showing our lensed galaxies (squares) and other comparison samples

→ **Our sources allow for the first time to probe the molecular gas content of z>1.5 galaxies in the LIRG regime**

→ **No 'bimodality' is observed any more between star-forming galaxies (local spirals and high-z) and ULIRGs/SMGs with the current, larger, available CO datasets**

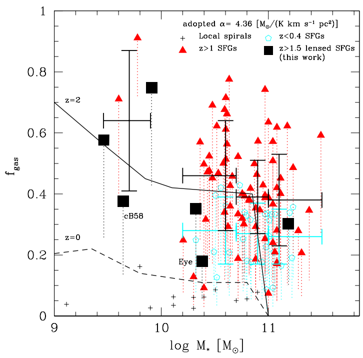
RIGHT:
Gas depletion timescale versus redshift

→**Clear evolution towards shorter timescales at high-redshift, despite the existence of large scatter. This 1.5(1+z)$^{-1.5}$ evolution (cyan shaded curve) agrees with the models of Davé et al. (2012)**



Gas fraction versus stellar mass

→ **A higher gas fraction is found at lower stellar masses, but also a large scatter; such an evolution is expected at high-z by the so-called « bathtub » models where gas mass and gas fraction are set by the balance of gas accretion from the halo (Bouché et al. 2010)**



Summary

- Our lensed sources, with a median magnification factor of 30, have L_{IR} which extend well below the Herschel blank field limit of the deepest fields. They probe the LIRG regime at z~2-3.
- The stellar masses, dust masses, IR luminosities, … of our sources are up to a factor ~10 below those of the faintest unlensed sources.
- We find several galaxies with unusually hot dust temperature (~45-50 K) at low IR luminosities ((1-4)*10^11 Lsun). The high temperatures are possibly related to intense star formation per unit gas or dust mass at high redshift.
- We find no 'bimodality' in L_{IR} vs L_{CO} between SFGs and ULIRGs/SMGs with the current, larger, available CO datasets.
- There is good evidence for a decreasing gas depletion timescale with redshift, reaching timescales of ~100 Myr at z~3. This is also suggestive of shorter star-formation timescales and more bursty star-formation at higher redshift, as suggested e.g. by LBG studies at z~3-6 (de Barros et al. 2012).
- Most galaxies at high-z show fairly high gas fractions; a gas fraction which is expected to increase toward lower stellar masses. This is also found for our galaxies with stellar masses M_* < 1x10^{10} $M_{\odot}$.