Towards the census of high-redshift dusty galaxies with *Herschel*: A selection of "500 μm-risers"

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Abstract

Herschel extragalactic surveys offer a unique opportunity to efficiently select a significant number of rare and massive dusty star forming galaxies (DSFGs), and thus gain insight into the prodigious star-forming activity that takes place in the very distant Universe. We developed a novel selection algorithm aiming to substantially increase the number of candidate unlensed, DSFGs at $z \geqslant 4$ and explain their statistics (Donevski et al. 2017, A&A in press, arXiv:1709.00942). To overcome the source confusion problem, we introduced prior-based source extraction linked with the spectral energy distribution (SED) fitting. We applied this innovative approach to the Herschel Virgo Cluster Survey field (HeViCS), the deepest contiguous 55 deg^2 field observed by *Herschel*. We defined model-based criteria to make a census of DSFGs with red SPIRE colours, so-called "500 μm-risers". We selected 133 "500 μm-risers" down to $S_{250} = 13.2$ mJy, which is the faintest known sample of red DSFGs. The sample contains some of the most prodigious DSFGs at $z > 4$, and provides important constraints on galaxy formation mechanisms. It is expected to unveil progenitors of massive quiescent galaxies at $z \sim 2 - 3$ (e.g. Toft et al. 2014).

We further interpreted the statistics of "500 μm-risers" with models, which has been proven as a very challenging task, mostly due the complexity of artefacts that affect their selection (Hayward et al. 2013, Bethermin et al. 2017). We made end-to-end simulations including lensing and physical clustering. We used abundance matching technique to populate the dark-matter halos of a light cone with modelled galaxies. After the careful quantification of observational biases we found that tension between models and observations can be partially solved, showing that noise and strong lensing have crucial impact on measured counts and redshift distribution of "500 μm-risers". The estimated fraction of strongly lensed sources is $24 \pm 5\%$ based on models. We further estimated flux-corrected star formation rate density at $4 < z < 5$ with the "500 μm-risers" and found it to be close to the total value measured in far-infrared (e.g. Bourne et al. 2016). This indicates that colour selection is not a limiting effect to search for the most massive, dusty $z > 4$ sources. The result highlights the importance to systematically explore the wide submillimetre areas to identify faint, unlensed DSFGs.