The Herschel View of Star Formation within Massive Merging Clusters

T. Rawle¹ (tim.rawle@sciops.esa.int), E. Egami², B. Altieri¹, P. Pérez-González³, J. Santos¹, I. Valtchanov¹, G. Walth² and the HLS Collaboration

¹ European Space Astronomy Centre (ESAC), ESA, ² University of Arizona, ³ Universidad Complutense Madrid

The “Herschel Lensing Survey” (HLS) comprises Herschel PACS+SPIRE maps of massive foreground clusters to investigate faint, high-redshift galaxies via gravitational lensing (see the HLS talk: E. Egami). Here, we explore those same images to view cluster galaxy evolution in two spectacular cluster mergers at $z\sim0.3$: the famous Bullet cluster (1E0657-558; Rawle +12), and the four-component Pandora’s cluster (Abell 2744; Rawle+in prep).

Combining deep far-infrared coverage from Herschel (which traces regions of ongoing, dusty activity), with existing multi-band observations, we explore the dust, stellar and AGN properties of star-forming cluster members, and assess the impact of cluster dynamics and substructure on the evolving galaxy population.

Fig. 1: Upper panels - HST colour images, overlaid by mass distribution from weak lensing (blue) and X-ray emission (pink) showing the effect of cluster merging.

Lower panels - Three-colour images, co-aligned with the upper panels: WISE 3.6, 4.5 µm and SPIRE 250 µm. White circles show Spitzer/Herschel-detected (star-forming) cluster galaxies. Their location does not appear correlated with cluster substructure (also, Chung+10).

We investigate the far-infrared properties further: dust continuum luminosity ($L_{\text{FIR}}$) is derived via the best-fitting template from Rieke+09, and dust temperature ($T_{\text{dust}}$) is from a single modified-blackbody fit.

Previous studies (e.g. Blain+03, Hwang+10) have identified a $L_{\text{FIR}}$–$T_{\text{dust}}$ relation. For $L_{\text{FIR}} < 10^{11} L_{\odot}$, $T_{\text{dust}}$ is relatively consistent at $\sim30$K. Only galaxies $\geq 10^{11} L_{\odot}$ exhibit $T_{\text{dust}}$ significantly above $\sim40$K.

All of the galaxies in A2744 conform to the relation observed in the large field samples (Fig. 2). One cluster member has $T_{\text{dust}} > 40$K (42 K), but it is also a very bright LIRG ($SFR \sim 50 M_{\odot}/yr$).

In contrast, we find several galaxies in the Bullet cluster with elevated $T_{\text{dust}}$ given their luminosity ($>37$ K at $L_{\text{FIR}} < 10^{11} L_{\odot}$; within the beige box). These sources are highlighted by squares in the above map.

We find that warm-dust galaxies do not exhibit power-law SED shapes or X-ray emission, which suggests that AGN are not responsible.

We provide a simple stripping model, in which dust is preferentially removed from the outskirts of a galaxy, where $T_{\text{dust local}}$ is lower (Engelbracht+10). 30–50% of dust, by mass, would need to be stripped from a normal star-forming galaxy to form an SED shape similar to the warm dust sources (Fig. 3).

Our ongoing analysis of Herschel cluster observations will explore how the warm dust population is produced in the Bullet cluster, but not in the similar cluster-merger A2744.


For further information, please contact tim.rawle@sciops.esa.int