The Herschel View of Star Formation within Massive Merging Clusters

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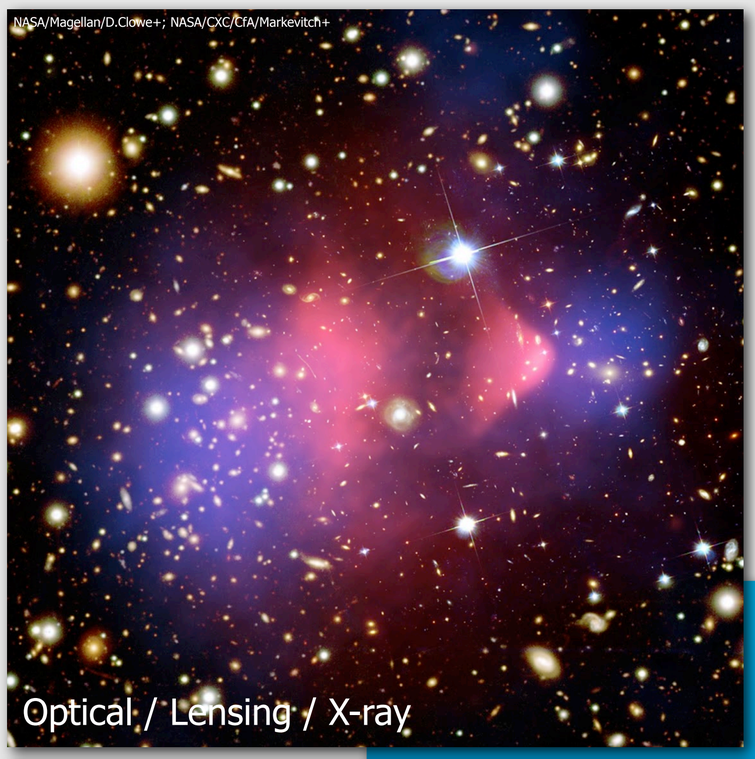
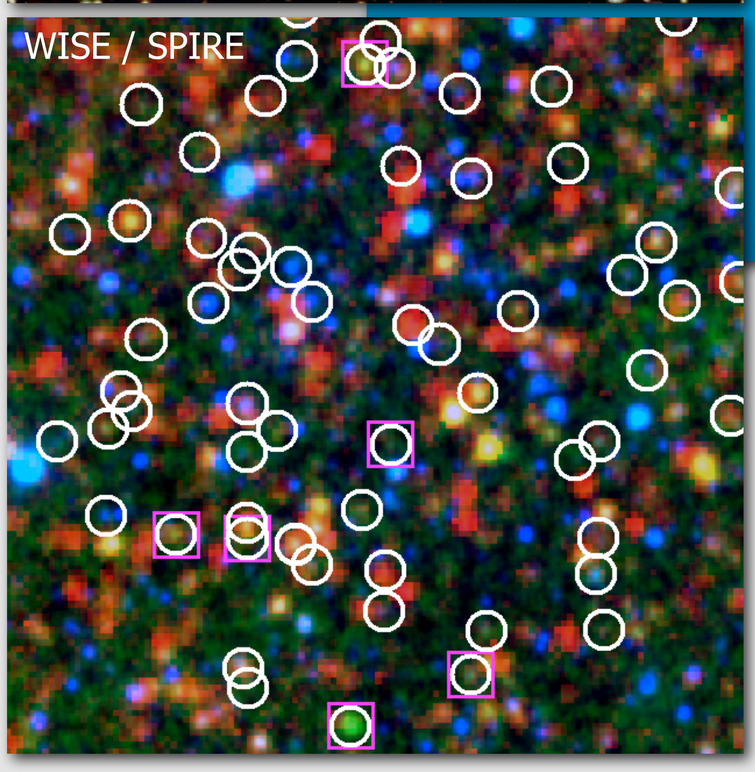
Bullet cluster





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~0.3: 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.

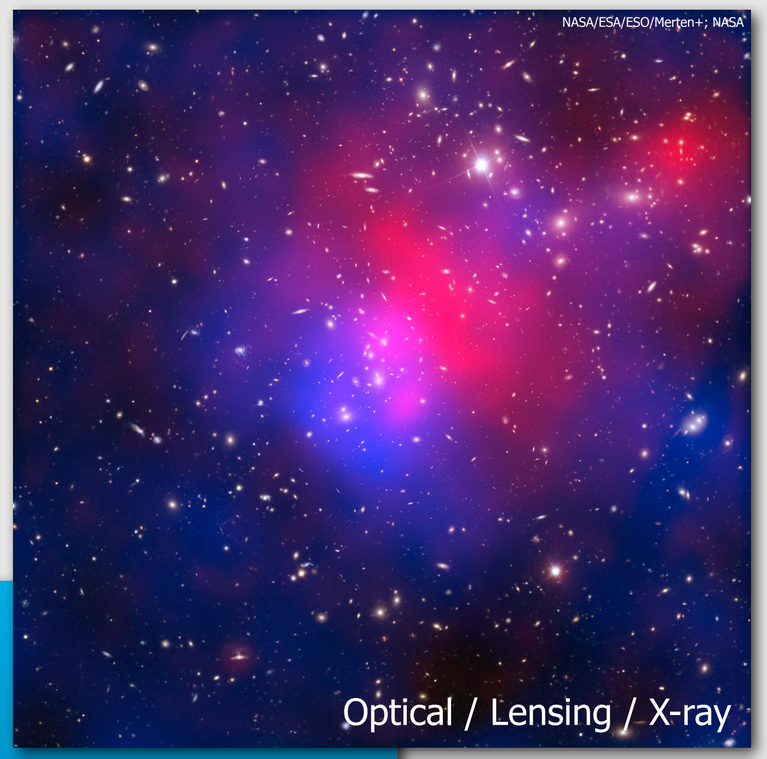
Fig. 1: Upper panels - HST colour images, overlaid by mass distribution from weak lensing (blue) and X-ray emission (pink) showing the effect of cluster merging.

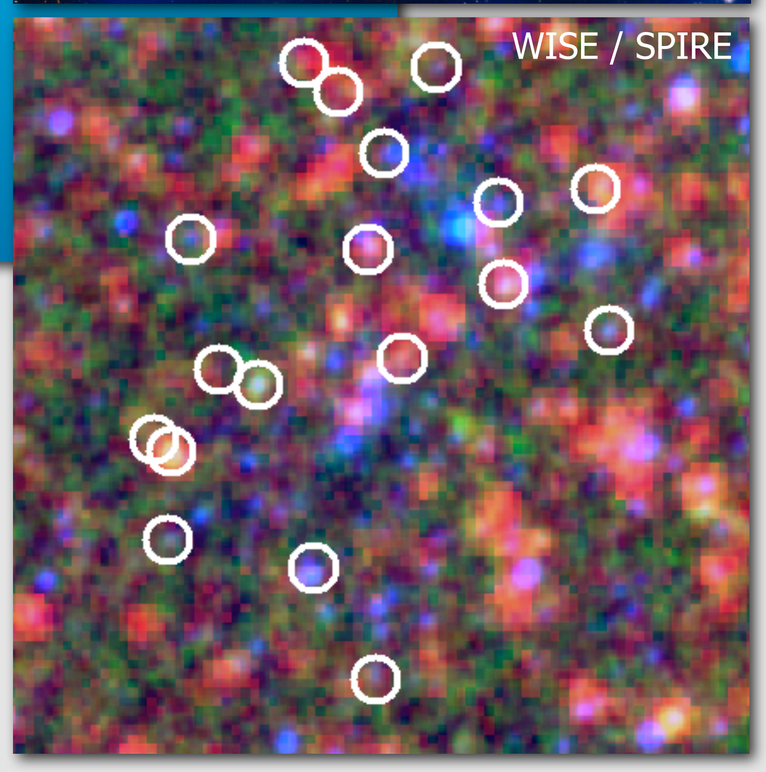
Lower panels - Three-colour images, co-aligned with the upper panels: WISE 3.6, 4.5 μm and SPIRE 250 μm. White circles show Spitzer/Herschel-detected (star-forming) cluster galaxies. Their location does not appear correlated with cluster substructure (also, Chung+10).

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

Previous studies (e.g. Blain+03, Hwang+10) have identified a L_{FIR}–T_{dust} relation. For $L_{FIR} < 10^{11}\ L_{\odot}$, T_{dust} is relatively consistent at ~30K. Only galaxies $\gg 10^{11}\ L_{\odot}$ exhibit T_{dust} significantly above ~40K.

Pandora's cluster (A2744)





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

In contrast, we find several galaxies in the Bullet cluster with elevated T_{dust} given their luminosity (>37 K at $L_{FIR} < 10^{11}\ L_{\odot}$; within the biege 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 $T_{dust,local}$ 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.

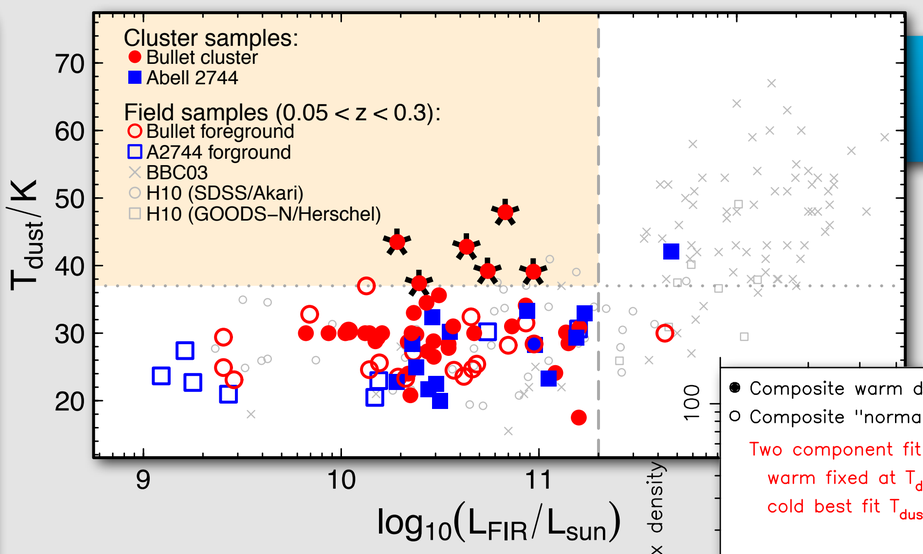


Fig. 2 - L_{FIR}–T_{dust} relation

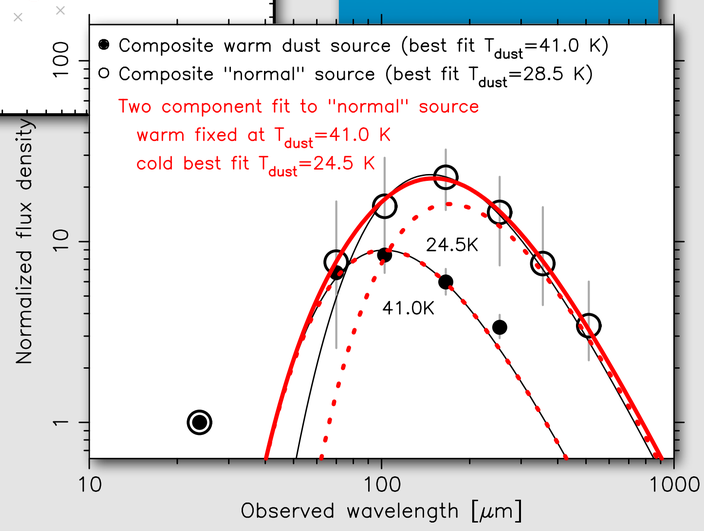


Fig. 3 - Dust stripping model

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References: Blain+03, MNRAS, 338, 733; Chung+10, ApJ, 725, 1536; Clowe+04, ApJ, 604, 596; Clowe+06, ApJ, 648, 109; Engelbracht+10, A&A, 518, 56; Hwang+10, MNRAS, 409, 75; Markevitch+04, ApJ, 606, 819; Merten+11, MNRAS, 417, 333; Rieke+09, ApJ, 692, 556