WIRE Ancillary Science - Diffuse Dust in Rich Galaxy Clusters

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The idea is to select one or more nearby 'rich' galaxy clusters and search for reddening in the mid-IR–to–optical colours of background (unassociated) sources by diffuse intracluster dust. Due to its relatively large covering factor, diffuse dust distributed on cluster scales causing a few-tenths magnitude extinction is most effective at obscuring background sources from optical flux-limited samples (eg. Masci 1998). In particular, there have been numerous claims of a deficit in background sources (eg. quasars) behind nearby clusters (Boyle 1988; Romani & Maoz 1992). Deficits of $\sim 30\%$ within $20'$ of the cluster centers were found, and it was proposed that dust extinction with $\langle A_B \rangle \simeq 0.5$ mag was responsible. Although there is considerable evidence for metal enriched gas from X-ray spectral observations, little direct evidence for associated dust exists. Motivated by these studies, we aim to directly constrain the dust optical depth on megaparsec scales using data from the WIRE 'moderate depth' survey and subsequent (or pre-planned) optical follow-up.

WIRE's suitability is threefold: First, the moderate survey will have an areal coverage ($\gtrsim$800 sq. degrees) to include large numbers of ideal cluster candidates. For instance, surveys for rich $z \lesssim 0.1$ clusters find a sky covering fraction 25-35%. For a typical optical radius $\sim 20'$, we therefore expect to find at least 500 rich cluster fields. Second, WIRE will have a sensitivity to detect large numbers of sources behind cluster fields to $z \simeq 2$. Third, selection at mid-IR wavelengths will be unbiased by foreground dust obscuration. This last point is important since it will allow us to constrain the amount of dust reddening by simply comparing the optical follow-up of mid-IR detections that fall within and outside cluster fields.

Our strategy then is to search for differential reddening between the average mid-IR–to–optical colour of sources lying *behind* (within) and *outside* rich cluster fields. We limit our analysis to low redshift ($z \lesssim 0.1$) rich clusters which typically have optical radii $10' - 30'$. This ensures that large numbers of background sources fall within the cluster fields and that foreground confusion with cluster members is minimised. Determination of cluster membership of a galaxy will be made on the basis of spectroscopic redshift. With a source density $\sim 700/\mathrm{deg}^2$ at $f_{25\mu\mathrm{m}} > 1.5$mJy ($5\sigma$) for a moderate evolution scenario, we expect a few hundred sources behind a cluster field spanning $\sim 30'$. No more than half of these are expected to be lost by merging or confusion with foreground cluster members. Allowing for a dispersion in intrinsic source colours, our statistics should be sufficient to provide unbiased (good average) sampling of the intracluster medium. Our method will be independent of any possible gravitational lensing by the cluster potential since it will equally affect mid-IR and optical source fluxes, leaving colours unchanged.

An estimate for the difference in mean source colours expected between fields within and outside a foreground cluster can be made by adopting the value $\langle A_B \rangle \simeq 0.5$ mag from the source deficit studies. Given the colour $C = \mathrm{Log}(f_{25\mu\mathrm{m}}/f_{440\mathrm{nm}})$, we expect a difference $\delta\langle C \rangle = 0.4\langle A_B \rangle \simeq 0.2$. A 10% uncertainty in both the measured optical and 25μm fluxes will lead to an uncertainty $\Delta C \sim 0.06$, significantly less than our expected differential reddening. Thus, if the previously claimed background source deficits are due to dust, then such a component should be easily detectable, or at least constrained as large as photometric errors allow.