Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

Mon. Not. R. Astron. Soc. **417,** 2831–2845 (2011) doi:10.1111/j.1365-2966.2011.19445.x

ACCESS – IV. The quenching of star formation in a cluster population of dusty S0s

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Accepted 2011 July 13. Received 2011 July 12; in original form 2011 May 6

ABSTRACT

We present an analysis of the mid-infrared (MIR) colours of 165 70-μm-detected galaxies in the Shapley supercluster core (SSC) at $z = 0.048$ using panoramic *Spitzer*/MIPS 24- and 70-μm imaging. While the bulk of galaxies show f_{70}/f_{24} colours typical of local star-forming galaxies, we identify a significant subpopulation of 23 70-μm-excess galaxies, whose MIR colours ($f_{70}/f_{24} > 25$) are much redder and cannot be reproduced by any of the standard model IR spectral energy distributions (SEDs). These galaxies are found to be strongly concentrated towards the cores of the five clusters that make up the SSC, and also appear rare among local field galaxies, confirming them as a cluster-specific phenomenon. Their optical spectra and lack of significant ultraviolet emission imply little or no ongoing star formation, while fits to their panchromatic SEDs require the far-IR emission to come mostly from a diffuse dust component heated by the general interstellar radiation field rather than ongoing star formation. Most of these 70-μm-excess galaxies are identified as $\sim L^*$ S0s with smooth profiles.

We find that almost every cluster galaxy in the process of star formation quenching is already either an S0 or Sa, while we find no passive galaxies of class Sb or later. Hence the formation of passive early-type galaxies in cluster cores must involve the *prior* morphological transformation of late-type spirals into Sa/S0s, perhaps via pre-processing or the impact of cluster tidal fields, before a *subsequent* quenching of star formation once the lenticular encounters the dense environment of the cluster core. In the cases of many cluster S0s, this phase of star formation quenching is characterized by an excess of 70-μm emission, indicating that the cold dust content is declining at a *slower* rate than star formation. We suggest that the excess 70-μm emission during quenching is due to either (i) a reduction of the star formation efficiency as proposed within the morphological quenching scenario or (ii) a 2–3 times increase in the dust-to-gas ratio or metallicity of the remaining interstellar medium, as predicted by chemical evolutionary models of galaxies undergoing ram-pressure stripping or starvation.

Key words: galaxies: clusters: general – galaxies: clusters: individual: A3558 – galaxies: clusters: individual: A3562 – galaxies: evolution – galaxies: star formation – infrared: galaxies.

1 INTRODUCTION

The evolution of a galaxy is a product of both nature and nurture – both of its mass, and of the environment in which the galaxy finds itself. Understanding the relative importance of nature and nurture remains a key issue in extragalactic astrophysics. These factors control the star formation rate (SFR) and the dynamical structure or morphology of the galaxy. In isolated galaxies, these observational quantities are largely determined by feedback processes acting within the interstellar medium (ISM) of the galaxy adjoined to its assembly history via mergers. In the harsh cluster environment,

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