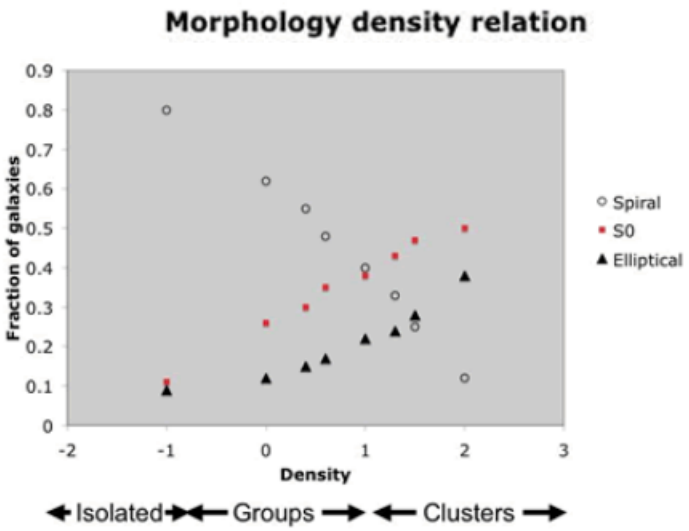
Morphology Density Relatonship

- The Relationship

  The morphology density relation is an observationally determined relationship between the morphological types (Hubble types) of galaxies and the environments in which they are located (in particular, how many galaxies per cubic megaparsec are found in the neighbourhood). It is shown below:-



  Specifically, the morphology density relation indicates that early-type (elliptical and S0) galaxies are preferentially located in high density environments, while late-type galaxies are preferentially located in low density environments. Hence, spiral galaxies are rare in the high densities of clusters and are common in isolation (and in the lower density group environment). Early-type galaxies, on the other hand, are common in clusters and are rarely found in isolation.

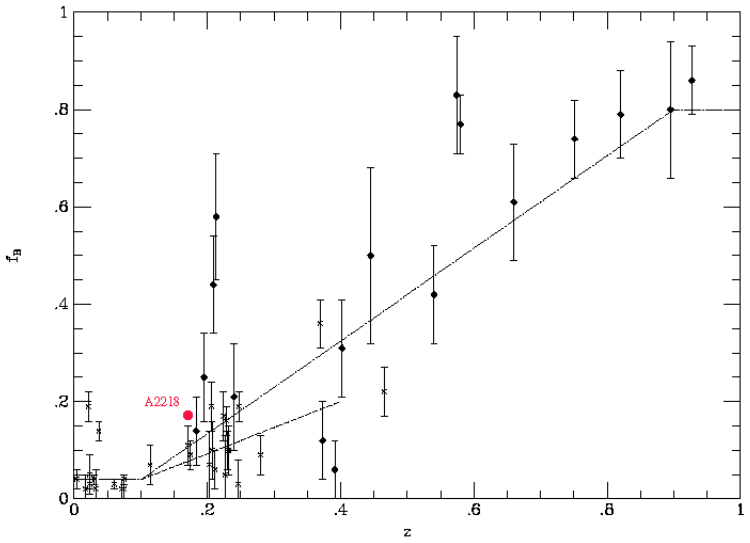
- Inferences

  The morphology density relation is believed to indicate that galaxy evolution is affected by the environment in which the galaxy finds itself. Specifically, there is strong evidence to suggest that star formation is suppressed when galaxies enter high density environments such a clusters. This suppression of star formation is not well understood, and a number of processes (including ram pressure stripping, galaxy strangulation and galaxy harassment) have been proposed to account for it.

Butcher-Oemler Effect

- The Effect

  Observations have shown that high redshift (high-z), rich galaxy clusters have an excess of galaxies with blue colours when compared to similar nearby (low redshift; low-z) clusters. This effect was first recognised in 1978 by Harvey Butcher and Augustus Oemler Jr, and is now known as the Butcher-Oemler effect.
  Following is an such an observation using 17 clusters between 0.2 and 1. The Butcher-Oemler effect is found to be very strong (as confirmed by spectroscopic and HST studies, e.g. van Dokkum et al 2001, Ziegler et al 2001, Kelson et al 2000). The plot represents fraction of blue galaxies vs redshift.



  More recent studies have further refined Butcher and Oemlers initial measurements, showing that the fraction of blue galaxies in rich clusters rises from approximately 3% for nearby (z<0.1) clusters, to 25% at z∼0.5 and reaching 70% by z∼1. These studies have also shown that the fraction of blue galaxies in clusters depends on the cluster type or richness (i.e. how many galaxies the cluster contains), the cluster-centric radius considered in the study (what distance from the centre is sampled), and the galaxy magnitude limit adopted.

- Clues about Galaxy Formation

  The overall trend of increasing blue galaxy fraction with increased lookback time is an important clue to how galaxies form. For example, the Butcher-Oemler effect can not be reproduced by simple primordial collapse models for galaxy formation, as such models predict uniformly red galaxies right back to high lookback times (i.e. z=2). This provides clear evidence that mergers and/or secular evolution must also play a part in galaxy formation.