Small Galaxy Groups
ASP Conference Series, Vol. 209, 2000
M. Valtonen and C. Flynn, eds.

The effects of galaxy winds on small galaxy groups

Stephen F. Helsdon and Trevor J. Ponman

School of Physics and Astronomy, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK

Abstract.
We present the largest survey to date of the X-ray properties of loose groups. We derive relations between X-ray luminosity, temperature and velocity dispersion, and also examine the surface brightness profiles of these systems. We find significant departures from the trends seen in galaxy clusters, which we interpret as arising from the effect of galaxy winds, and we briefly compare the properties of these loose groups with those of compact groups.

1. Introduction

The detection of extended X-ray emission from hot gas in a group potential well provides the best evidence that the group is truly gravitationally bound. Study of this hot intra-group gas can provide important insights into the evolution and dynamics of groups and their member galaxies.

Preheating by galaxy winds associated with galaxy formation can leave an imprint in the intergalactic medium. This effect should be greatest in small galaxy groups in which the shallower potential well enables the effects to be more clearly seen. This has already been reported in compact groups (Ponman et al. 1996), but these only represent a few percent of all groups. Previous work on the X-ray properties of loose groups (e.g. Burns et al. 1996, Mulchaey et al. 1996, Mahdavi et al. 1997, Mulchaey & Zabludoff 1998) have not provided a uniform, detailed analysis of a reasonable sized sample of groups, due to either a small sample size or the use of ROSAT All Sky Survey (RASS) data, in which short exposures, and thus poor statistics, limit the analysis of any particular group.

2. X-ray properties of loose groups

In a recent paper (Helsdon & Ponman 1999a) we have studied a sample of 24 X-ray bright loose groups observed with the ROSAT PSPC. We identify and remove all point sources in the region of the group to investigate both the spectral and spatial properties of the diffuse intragroup emission. We fit hot plasma models to determine temperatures, allowing us to derive the relation between X-ray luminosity and temperature (Figure 1) and the relation between temperature and group velocity dispersion (Figure 2). The best fit line is plotted

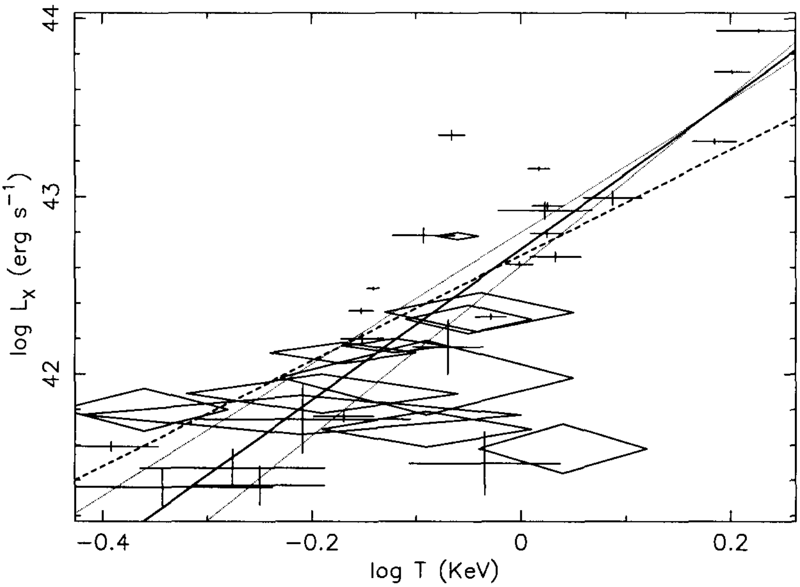

Figure 1. X-ray luminosity-temperature relation for loose groups (crosses). The solid line is the best fit to the loose and compact group sample, with 1σ error bounds. The dashed line is an extrapolation of the White et al. (1997) cluster relation. Also shown for comparison are compact group data points (diamonds) from Ponman et al. (1996).

along with 1σ error bounds on the L:T relation. The line $\beta_{\rm spec} = 1$ is plotted on the σ:T relation. $\beta_{\rm spec}$ is the ratio of the specific energy in the galaxies to that of the gas. Points below the line have an excess of energy in the gas, those above an excess in the galaxies. Also plotted for comparison on both graphs are the Hickson compact group data points from Ponman et al. (1996). It appears that these compact systems follow the same relationships as loose groups (Helsdon & Ponman 1999b), suggesting that they are not fundamentally different. The L:T relation from the combined loose and compact sample has a slope of 4.3 ± 0.5 which is steeper than predicted from self similar scaling or from an extrapolation of the cluster relation. The lower temperature points on the σ:T relation generally fall below the line $\beta_{\rm spec} = 1$.

Two dimensional β profiles are fit to the spatial data. Following Mulchaey & Zabludoff (1998) who show that two components are required to adequately fit the surface brightness profiles of most groups, we also fit two component models to the groups with sufficient statistics. The median value of $\beta_{\rm fit}$ for the full sample using two-component fits where available, or else single-component fits, is $\beta_{\rm fit} = 0.46$, indicating a flatter profile than the typical $\beta_{\rm fit} \approx 2/3$ observed in clusters. Shown in Figure 3 is the relationship between $\beta_{\rm fit}$ of the extended component and temperature for a subsample of the groups for which good quality two component fits were obtained. Also shown for comparison is a selection of

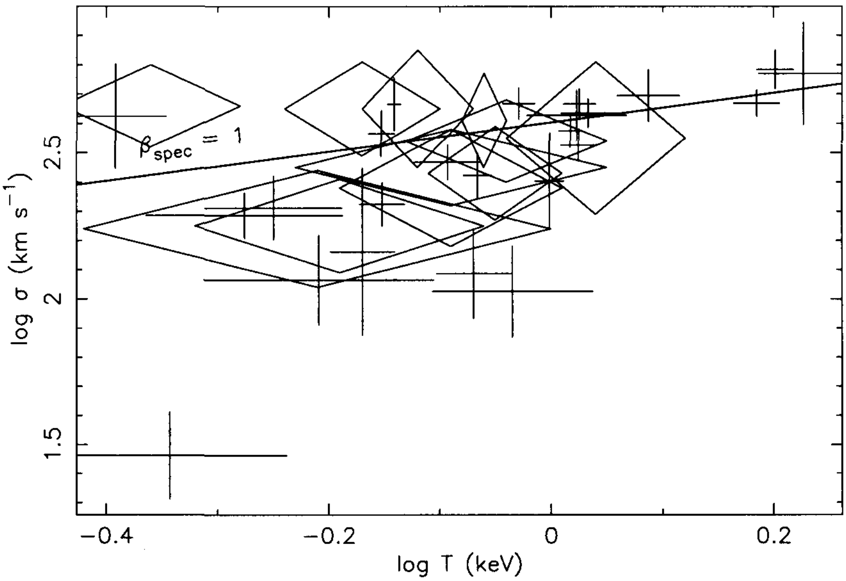

Figure 2. Velocity dispersion-temperature relation for loose groups (crosses). The solid line shows $\beta_{\rm spec} = 1$. Also shown for comparison are compact group data points (diamonds) from Ponman et al. (1996).

cluster data from Arnaud & Evrard (1999). As can be seen there is a general trend towards flatter profiles in cooler systems.

3. Evidence for preheating

The primary effect of preheating is to add energy to the gas, which in turn causes the gas to resist compression, and thus reduce its density within the potential well of groups. There is likely to be some increase in temperature but the dominant effect should be a reduction in the luminosity (due to the n^2 dependence of luminosity). Thus for a fixed temperature the luminosity will be reduced, resulting in a steepening of the L:T relation, as observed.

Further evidence is provided by the σ:T relation, in which the lowest temperature groups have a low value of $\beta_{\rm spec}$, suggesting an excess of energy in the intragroup gas of these systems, consistent with the idea that energy has been injected. Finally the flat surface brightness profiles of these systems provide further evidence that energy has been injected causing the gas to collapse less, producing flatter profiles.

Taken together we believe that these three pieces of evidence strongly suggest that preheating has taken place in these galaxy systems, most likely due to galaxy winds at the time of galaxy formation.

https://doi.org/10.1017/S0252921100054968 Published online by Cambridge University Press

Acknowledgments. We would like to thank E. Lloyd-Davies for his assistance with this work.

References

Arnaud, M., Evrard, A. E., 1999, preprint, astro-ph/9806353

Burns, J. O., Ledlow, M. J., Loken, C., Klypin, A., Voges, W., Bryan, G. L., Norman, M. L. & White, R. A. 1996, ApJL, 467, L49

Helsdon S. F., Ponman T. J., 1999a, MNRAS, submitted

Helsdon S. F., Ponman T. J., 1999b, in prep.

Mahdavi, A., Boehringer, H., Geller, M. J., Ramella, M., 1997, ApJ, 483, 68

Mulchaey, J. S., Davis, D. S., Mushotzky R. F., Burstein, D., 1996, ApJ, 456, 80

Mulchaey, J. S., Zabludoff, A. I., 1998, ApJ, 496, 73

Ponman, T. J., Bourner, P. D. J., Ebeling, H., Bohringer, H., 1996, MNRAS, 283, 690

White, D. A., Jones, C., Forman, W., 1997, MNRAS, 292, 419

https://doi.org/10.1017/S0252921100054968 Published online by Cambridge University Press

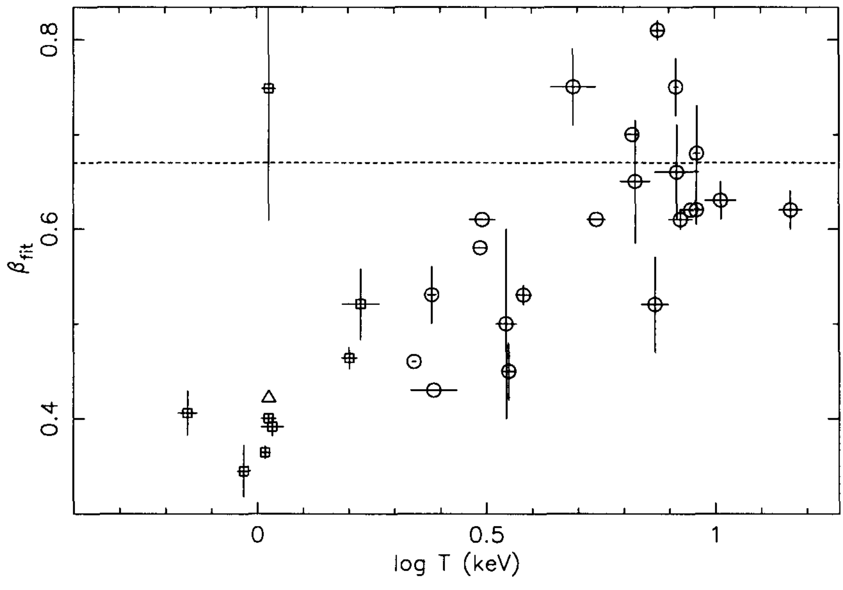

Figure 3. β_{fit} and temperature for good quality group data (crosses with central squares). Also shown are cluster data from Arnaud & Evrard (1999) (crosses with central circles). The dashed line indicates the canonical value of β_{fit} $\approx$0.67 used for clusters. The one discrepant group point is sensitively dependent on the shape of the central component. Using a Gaussian central component rather than a β profile can move this point to the position marked by the triangle.

https://doi.org/10.1017/S0252921100054968 Published online by Cambridge University Press