

Investigating the Dynamical State of Galaxy Clusters Hosting Radio Haloes



Marcelina Kinyumu, School of Physics, University of the Witwatersrand

Supervisors: Prof. M. Hilton , Dr. K. Knowles Rhodes University



Introduction

Discovery of giant radio haloes (GRHs) in merging galaxy clusters links cluster dynamics with intracluster non-thermal emission [1]

With GRHs as likely transient phenomena, having their radio brightness and morphology depending upon

- State of the merger
- Masses of the merging components

In the context of the turbulent re-acceleration model clusters hosting GRHs are expected to be undergoing mergers

Data Sample

Galaxy clusters detected by the Atacama Cosmology Telescope [2] with radio halo detections

Obtaining spectroscopic data from Southern Africa Large telescope (SALT) for MeerKAT Exploration of Relics, Giant Halos and Extragalactic Radio Source (MERGHERS) clusters [3]

A Radio Halo Example

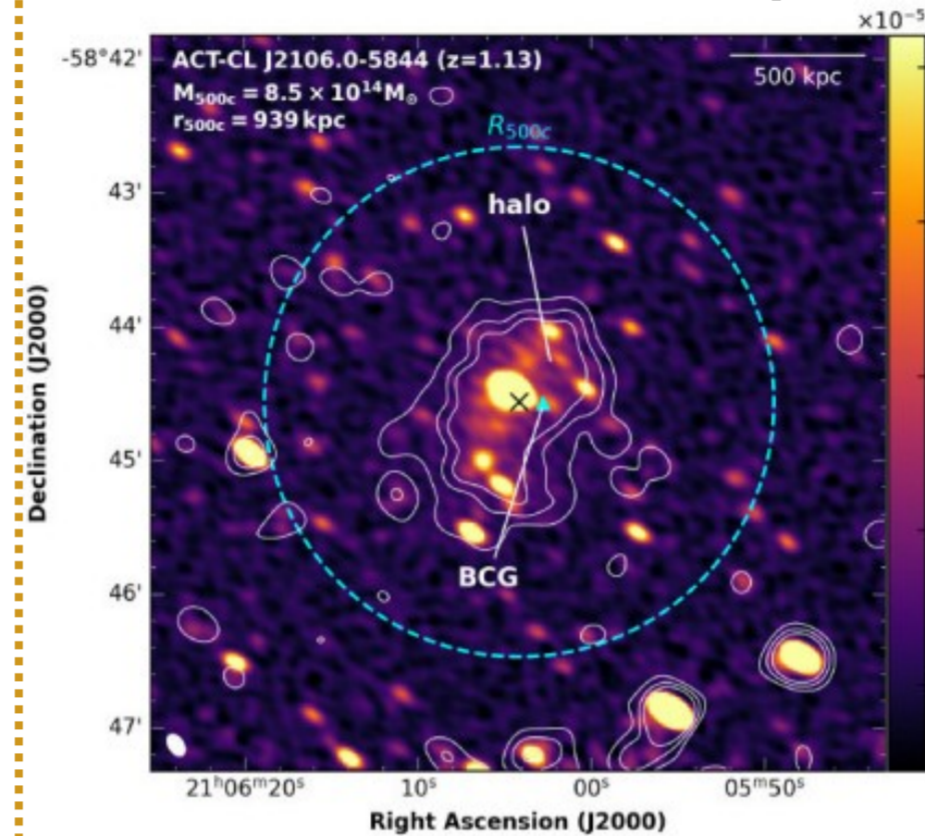


Fig 1. A radio halo in galaxy cluster J2106 detected by the MeerKAT Massive Distant Clusters Survey (MMDCS) [4]

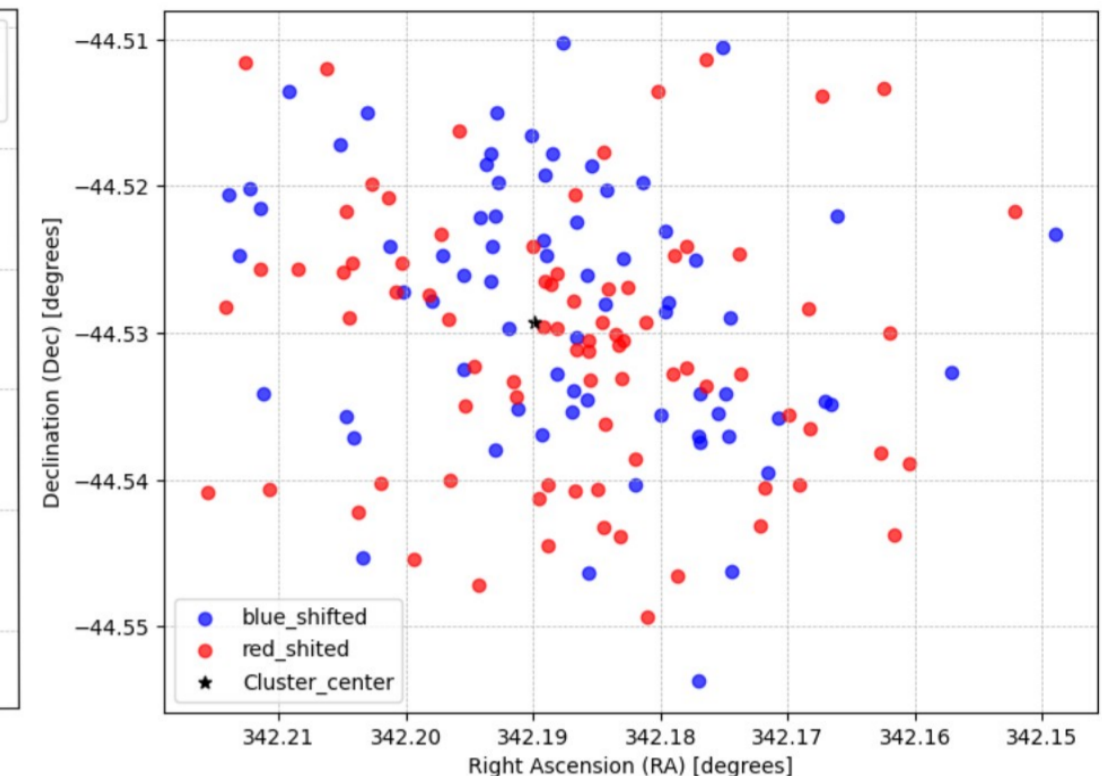
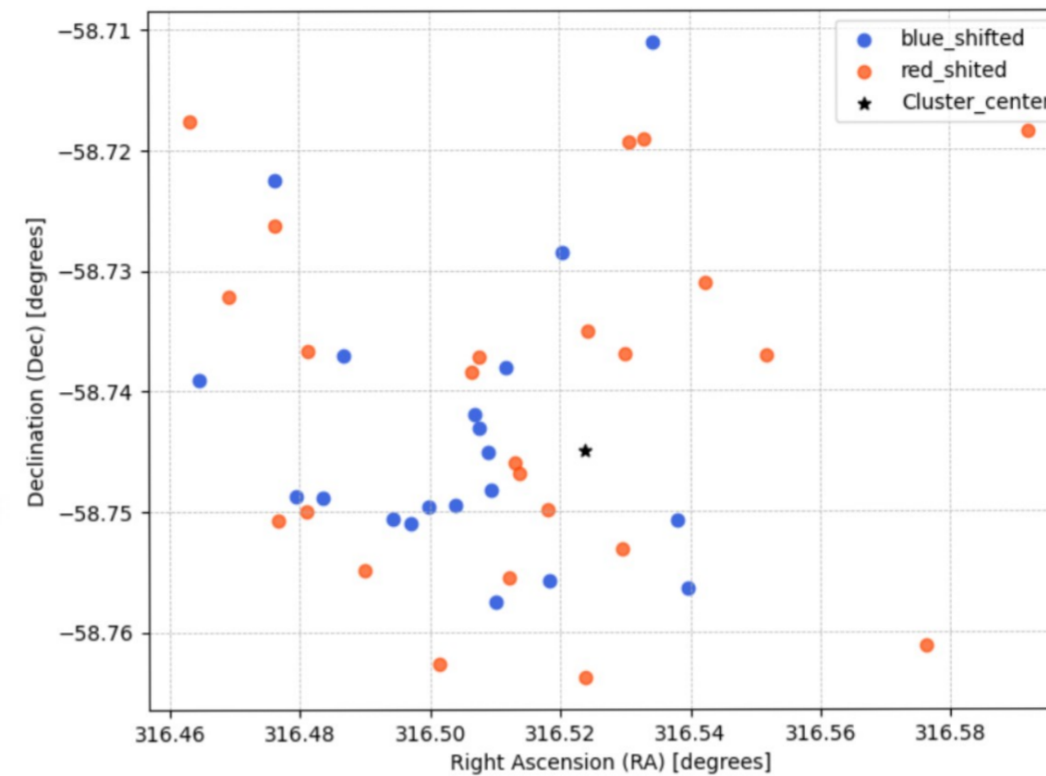


Fig 2. Redshift distribution of 44 **J2106** cluster members ($z = 1.132$), with spec z from Gogreen DR2 [5] on the left. The distribution of 153 **Abell S1063** cluster members ($z = 0.351$), with spec z from CLASH-VLT [6] is on the right. **Abell S1063** radio halo was detected by MeerKAT Galaxy Clusters Legacy Survey (MGCLS) and references there in [7]

Gaussian mixture model (GMM) substructure

- GMM fits 2-mode gaussian mixtures. We compare with a unimodal fit (use peculiar velocities of member galaxies)
- Obtain Kurtosis (K), maximum log likelihood, $\log L$ [$\Delta \log L = 2 \times (\log L_{\text{bimodal}} - \log L_{\text{unimodal}})$] and for bimodal, the peak separation of the model relative to their width (D)
- Evidence of 2 components is give by $K < 0$, $\Delta \log L > 0$ and/or $D > 2$

Analysis

Cluster dynamical state through optical spectroscopy observations

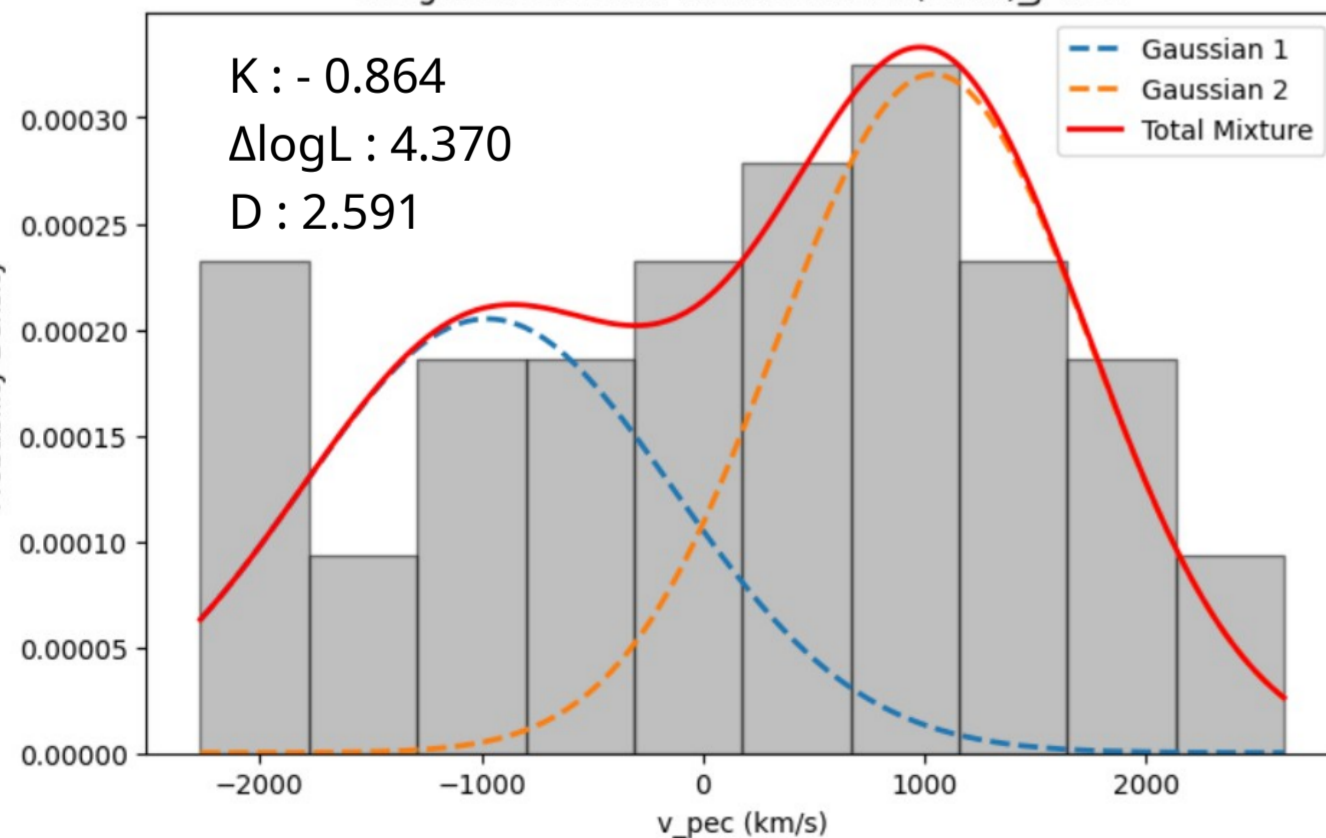
- Measure secure spectroscopic redshifts (60 per cluster) [8]
- Investigate sub-structure in the line of sight (velocity difference)
- Dynamical mass measurements of merging components

Investigate the relationship between the merger state and radio power

Reference

1. Van Weeren, R. J., et al., 2029, Spece Sci. Rev., 215,16
2. ACT-DES-HSC Collaboration 2025
3. Knowles, K., et al., 2021, MNRAS, 504, 1749
4. Phuravhathu, D. G., et al., 2025, MNRAS, 542, 1544
5. Balogh, M. L., et al., 2021, MNRAS, 500, 358
6. Mercurio, A., et al., 2021, A&A, 656, A147
7. Knowles, K., et al., 2022, A&A 657, A56
8. Sifón, C., et al. 2013 ApJ, 772(1), 25

Weighted Gaussian Mixture Model (GMM) J2106



Weighted Gaussian Mixture Model (GMM) Abell S1063

