November 2, 2010

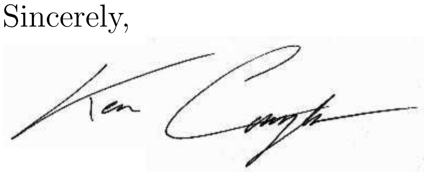
Grainger Search Committee
University of Wisconsin
Astronomy Department
475 N. Charter Street
Madison, WI 53706
USA

To whom it may concern:

Please find attached my 2011 Grainger Fellowship application titled "Mapping Galaxy Cluster Magnetic Fields: An Observational Study of ICM Physics." I feel the University of Wisconsin-Madison (UW) is an excellent fit for my research goals and the professional environment will benefit from my addition. The UW Astronomy and Physics Departments, Center for Plasma Theory & Computation, and Center for Magnetic Self-Organization are home to numerous experts in one, or several, of the science areas discussed in this proposal (*e.g.* X-ray/radio/polarization studies of galaxy clusters, AGN feedback, computational modeling, high-energy astronomy, plasma physics). Their experience with the latest techniques in all these disciplines will be invaluable to the success of my proposed work. In addition, my expertise in X-ray and radio astrophysics, and mature collaborations with groups in both research areas, has prepared me for the rigors of the program proposed in this application.

Along with this letter are my curriculum vitae, a list of publications, and a statement of my proposed research program. Letters of recommendation from Dr. Megan Donahue, Dr. Mark Voit, and Dr. Brian McNamara should arrive under separate cover. Please do not hesitate to contact me if there is any further information I can provide as you review my application. Thank you for your consideration.

Sincerely,



Kenneth W. Cavagnolo

Kenneth W. Cavagnolo
Curriculum Vitae

Observatoire de la Côte d'Azur	Citizenship: U.S.A.
Boulevard de l'Observatoire	Marital Status: Married
B.P. 4229	Birthdate: Jan. 27th, 1980
F-06304, Nice CEDEX 4, France	kencavagnolo@gmail.com
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Education

Michigan State University — 2005 – 2008
Ph.D., Astronomy & Astrophysics

Michigan State University — 2002 – 2005
M.S., Astronomy & Astrophysics, *magna cum laude*

Georgia Institute of Technology — 1998 – 2002
B.S., Physics, *magna cum laude*

Research Experience

Opales Postdoctoral Fellow — 2010 – Present
Supervisor: Chiara Ferrari, *Obs. Côte d'Azur*

UW Postdoctoral Fellow — 2008 – 2010
Supervisor: Brian McNamara, *Univ. of Waterloo*

Graduate Research Assistant — 2003 – 2008
Supervisor: Megan Donahue, *Mich. St. Univ.*

Graduate Research Assistant — 2002 – 2003
Supervisor: Jack Baldwin, *Mich. St. Univ.*

Undergraduate Research Assistant — 2000 – 2002
Supervisor: James Sowell, *Geor. Inst. of Tech.*

Research Program & Interests

My research program is focused on better understanding the physics of the intracluster and intragroup medium, and the role of feedback from active galactic nuclei & quasars on the formation and evolution of galaxies, galaxy groups, and galaxy clusters.

Specific areas of interest:
- Cosmic magnetic fields
- Non-thermal galaxy cluster emission
- Black hole accretion physics
- Relativistic jets
- Cosmological studies of structure formation

Honors

• Referee for ApJ, ApJL, AJ, CanTAC, & MNRAS	2008 – Present
• Sherwood K. Haynes Award for Outstanding Graduate Student	2008
• MSU College of Natural Science Dissertation Fellow	2007 – 2008
• ΣΞ National Scientific Research Society Member	2009 – Present
• ΣΠΣ National Physics Honor Society Member	2001 – Present
• American Astronomical Society Member	2002 – Present

- American Physical Society Member — 2002 – Present
- LOFAR Consortium Member — 2010 – Present
- Perimeter Institute Black Hole Reading Group Member — 2009 – 2010
- Dean's List, Georgia Inst. of Tech. — 1998 – 2002

Scientific Skills

- Expert of radio and X-ray data analysis & interpretation
- Extensive experience analyzing infrared, optical, UV, and gamma-ray data
- Mastery of AIPS, CASA, CIAO, IRAF, OSA, and SAS analysis software
- Fluent in HTML, IDL, LaTeX, and PERL programming languages
- Familiar with C, FORTRAN, MYSQL, PYTHON, SUPERMONGO, and TCL
- Command of DOS, Linux, Macintosh, and Windows computing architectures
- Skillful in computer maintenance, construction, and troubleshooting

Observing Experience

Very Long Baseline Array (VLBA) — TBD
12 hours observing IRAS 09104+4109

Giant Metrewave Radio Telescope (GMRT) — Jan. 2010
60 hours observing 15 galaxy clusters

Chandra X-ray Observatory (CXO) — Jan. 2009
21 hour queued observation of IRAS 09104+4109

Very Large Array Radio Telescope (VLA) — Dec. 2008
39 hours observing 13 giant ellipticals

Accepted Proposals & Grants

VLBA Cycle 10, PI — 2010
Imaging the Misdirected QSO of IRAS 09104+4109

GMRT Cycle 17–19, Co-I — 2009 – 2010
Power and Particle Content of Extragalactic Radio Sources I–III
PI: Somak Raychaudhury, *Univ. Birmingham*

GMRT Cycle 17, Co-I — 2009
Morphology of Steepest Spectrum Radio Sources in Galaxy Cluster Cores
PI: Alastair Edge, *Durham Univ.*

NOAO Cycle 2008A, 2009A/B, & 2010A, Co-I — 2008 – 2010
Normalization and scatter of the $M-T$ relation for supermassive galaxy clusters
PI: Rachel Mandelbaum, *Princeton Univ.*

GMRT Cycle 16, Co-I — 2008
Content of Giant Cavities in the IGM of Galaxy Clusters
PI: Somak Raychaudhury, *Univ. Birmingham*

CXO Cycle 10, PI — 2008
IRAS 09104+4109: An Extreme Brightest Cluster Galaxy

CXO Cycle 10, Co-I — 2008
Conduction and Multiphase Structure in the ICM
PI: Mark Voit, *Mich. St. Univ.*

Spitzer Cycle 5, Co-I — 2008
Star Formation and AGN Feedback in BCGs
PI: Megan Donahue, *Mich. St. Univ.*

Spitzer Cycle 5, Co-I — 2008
Infrared Properties of a Control Sample of Brightest Cluster Galaxies
PI: Megan Donahue, *Mich. St. Univ.*

NSF Grant, Co-I — 2008
Star Formation in the Universe's Largest Galaxies
PI: Mark Voit, *Mich. St. Univ.*

CXO Cycle 9, Co-I — 2007
Quantifying Cluster Temperature Substructure
PI: Mark Voit, *Mich. St. Univ.*

VLA A-configuration Cycle, Co-I — 2007
Radio Feedback in Clusters and Galaxies
PI: Brian McNamara, *Univ. Waterloo*

Students Advised

Clif Kirkpatrick, Ph.D. candidate, *Univ. Waterloo* — 2008 – 2010
The 2-Dimensional metal abundance distributions in galaxy clusters

Mina Rohanizadegan, Ph.D. candidate, *Univ. Waterloo* — 2008 – 2010
Understanding SMBH accretion and spin

Jason King, Undergraduate research, *Univ. Waterloo* — 2010
Quantifying scatter in the $P_{\rm jet}$-$P_{\rm radio}$ relation

Brad Whuiska, Undergraduate research, *Univ. Waterloo* — 2009
Finding the largest galactic cores in the *HST* archive

Rob Myers, Undergraduate research, *Univ. Waterloo* — 2009
In search of galaxy cluster radio galaxies in the 400 deg^2 Survey

Outreach

Non-thermal Phenomena in Colliding Galaxy Clusters — 2010
Conference Local Organizing Committee

International Year of Astronomy — 2009
Organized observing nights, talks, and workshops in Waterloo, ON

Teaching Experience

Substitute Instructor — Fall 2006
Course: "Visions of the Universe"

Honors Physics Tutor — Summer 2003
Course: "Introductory Honors Physics I & II"

Graduate Teaching Assistant — 2002 - 2003
Course: "Visions of the Universe"

References

Megan Donahue, donahue@pa.msu.edu — 517-884-5618
Tenured faculty, Michigan State University

G. Mark Voit, voit@pa.msu.edu 517-884-5619
Tenured faculty, Michigan State University

Brian McNamara, mcnamara@uwaterloo.ca 519-888-4567 ext. 38170
Tenured faculty, University of Waterloo

Chris Carilli, ccarilli@nrao.edu 575-835-7306
Chief Scientist, National Radio Astronomy Observatory

Jack Baldwin, baldwin@pa.msu.edu 517-884-5611
Associate Chair of Astronomy, Michigan State University

Mike Wise, wise@science.uva.nl 05-2159-5564
Chief Scientist, LOFAR Radio Observatory

Paul Nulsen, pnulsen@cfa.harvard.edu 617-495-7043
Research Scientist, Center for Astrophysics at Harvard University

Chiara Ferrari, ferrari@oca.eu 04-9200-3028
Adjunct Astronomer, Observatoire de la Côte d'Azur

Personal Interests

- Academic: Environmental sciences, "Cradle2Cradle" design, and urban planning.
- Athletics: Triathlons, running, baseball, and Georgia Tech athletics.
- Hobbies: Backpacking, reading, building model airplanes, and raising bonsai trees.

Kenneth W. Cavagnolo
Publications

Submitted

"Direct Evidence of Radiative and Mechanical Feedback from the Quasar in IRAS 09104+4109"
K. Cavagnolo, M. Donahue, B. McNamara, G. M. Voit, & M. Sun
Submitted to MNRAS

"A Powerful, Line-of-Sight AGN Outburst in RBS 797"
K. Cavagnolo, B. McNamara, M. Wise, P. Nulsen, M. Brüggen, M. Gitti, & D. Rafferty
Submitted to ApJ

In Preparation

"Identifying AGN Feedback Relics Via Steep Spectrum Radio Sources"
K. Cavagnolo, A. Edge, H. Röttgering, B. McNamara, M. Wise, M. Brüggen, R. van Weeren, G. Brunetti, & J. Croston
In prep. for A&A

"Entropy Scaling Relations of ACCEPT Galaxy Clusters"
K. Cavagnolo, G. M. Voit, M. Donahue, & S. Bruch
In prep. for ApJL

"How Difficult is SMBH Spin Axis Reorientation? Implications for AGN Feedback Models"
K. Cavagnolo & N. Afshordi
In prep. for ApJL

"The Radio Halo-Merger-Cooling Connection in Galaxy Clusters at $z \sim 0.5$"
E. Orrù, C. Ferrari, M. Arnaud, **K. Cavagnolo**, J. Croston, N. Jetha, G. Pratt, E. Pointecouteau, & S. Raychaudhury
In prep. for A&A

"Redistribution of Metals in Galaxy Clusters via AGN Feedback"
C. Kirkpatrick, B. McNamara, **K. Cavagnolo**, P. Nulsen, & M. Wise
In prep. for ApJ

"Normalization and Scatter of the M–T Relation for Supermassive Galaxy Clusters"
R. Mandelbaum, R. Nakajima, N. Bahcall, G. Bernstein, **K. Cavagnolo**, M. Donahue, J. Hughes, C. Keeton, A. Kravtsov, S. Miyazaki, N. Padmanabhan, & T. Schrabback
In prep. for ApJ

First Author Refereed

"A Relationship Between AGN Jet Power and Radio Luminosity"
K. Cavagnolo, B. McNamara, P. Nulsen, C. Carilli, C. Jones, & L. Bîrzan
ApJ Published, 2010

"Intracluster Medium Entropy Profiles for a Chandra Archival Sample Of Galaxy Clusters"
K. Cavagnolo, M. Donahue, G. M. Voit, & M. Sun
ApJ Published, 2009

"An Entropy Threshold for Strong Hα and Radio Emission in the Cores of Galaxy Clusters"
K. Cavagnolo, M. Donahue, G. M. Voit, & M. Sun
ApJ Published, 2008

"Bandpass Dependence of X-Ray Temperatures in Galaxy Clusters"
K. Cavagnolo, M. Donahue, G. M. Voit, & M. Sun
ApJ Published, 2008

Co-Author Refereed

"Direct Evidence for an Outflow of Metal-Enriched Gas Along the Radio Jets of Hydra A"
C. Kirkpatrick, M. Gitti, **K. Cavagnolo**, B. McNamara, L. David, P. Nulsen, & M. Wise
ApJL Published, 2009

"A Chandra X-ray Analysis of Abell 1664: Cooling, Feedback and Star Formation in the Central Cluster Galaxy"
C. Kirkpatrick, B. McNamara, D. Rafferty, P. Nulsen, L. Birzan, F. Kazemzadeh, M. Wise, M. Gitti, & **K. Cavagnolo**
ApJ Published, 2009

"Conduction and the Star Formation Threshold in Brightest Cluster Galaxies"
G. M. Voit, **K. Cavagnolo**, M. Donahue, D. Rafferty, B. McNamara, & P. Nulsen
ApJ Published, 2008

"Star Formation, Radio Sources, Cooling X-Ray Gas and Galaxy Interactions in the Brightest Cluster Galaxy in 2A0335+096"
M. Donahue, M. Sun, C. O'Dea, G. M. Voit, & **K. Cavagnolo**
AJ Published, 2007

"s-Process Abundances in Planetary Nebulae"
B. Sharpee, Y. Zhang, R. Williams, E. Pellegrini, **K. Cavagnolo**, J. Baldwin, M. Phillips, & X. Liu
ApJ Published, 2007

"Entropy Profiles in the Cores of Cooling Flow Clusters of Galaxies"
M. Donahue, D. Horner, **K. Cavagnolo**, & G. M. Voit
ApJ Published, 2006

Presented Work

INVITED TALK: *"Exploring the Radio-mode/Quasar-mode Feedback Dichotomy"*
Nov. 2010 – CNRS Colloquium; Observatoire de la Côte d'Azur

TALK: *"The AGN Jet Power and Radio Power Relationship"*
Jun. 2009 – The Monster's Fiery Breath Meeting; University of Wisconsin-Madison

INVITED TALK: *"Using Galaxy Clusters as Galaxy Formation Labs"*
Oct. 2008 – Undergraduate Seminar Series; University of Waterloo

INVITED TALK: *"Understanding Cluster Cores: The Role of Core Entropy"*
Sept. 2008 – The Cool, Cooler, and Cold Meeting; Leiden University

INVITED TALK: *"Investigating Feedback and Relaxation in Clusters of Galaxies"*
Jul. 2008 – Center for Study of Cosmic Evolution; Michigan State University

INVITED TALK: *"From Cluster Cosmology to Galaxy Formation in Under One Hour"*
Mar. 2008 – Astrophysics Seminar; University of Waterloo

INVITED TALK: *"The Effect of Cluster Feedback on High-Precision Cosmology"*
Feb. 2008 – NASA Space Science and Technology Center; University of Alabama-Huntsville

INVITED TALK: *"Understanding Feedback in Galaxy Clusters"*
Jan. 2008 – Center for Study of Cosmic Evolution; Michigan State University

INVITED TALK: *"Band Dependence of X-ray Temperatures"*
Oct. 2007 – Astrophysics Seminar; University of Michigan

POSTER: *"The Entropy-Feedback Connection and Quantifying Cluster Virialization"*
Oct. 2007 – Eight Years of Science with Chandra; University of Alabama-Huntsville

POSTER: *"Chandra Studies of Dark Matter and Galaxy Formation: Signatures from the Intracluster Medium"*
Dec. 2006 – American Astronomical Society Meeting

PROCEEDING: *"Abundances of s-process elements in planetary nebulae: Br, Kr & Xe"*
Jul. 2006 – International Astronomical Union Symposium

POSTER: *"Studies of Entropy Distributions in X-ray Luminous Clusters of Galaxies"*
Dec. 2005 – American Astronomical Society Meeting

POSTER: *"Entropy Distributions in the Cores of Nearby X-ray Luminous Clusters of Galaxies"*
Dec. 2004 – American Astronomical Society Meeting

POSTER: *"Radio-Free Cluster Cooling Flows"*
Dec. 2004 – American Astronomical Society Meeting

MAPPING GALAXY CLUSTER MAGNETIC FIELDS: AN OBSERVATIONAL STUDY OF ICM PHYSICS

I. Motivation

Clusters of galaxies are the largest structures in the Universe to have reached dynamic equilibrium, and most cluster baryonic mass resides in the intracluster medium (ICM), a hot, dilute, weakly magnetized plasma filling a cluster's volume [1]. As the defining characteristic of the most massive objects in the Universe, the thermal properties of the ICM are well-known, but a similarly detailed description of ICM non-thermal properties – specifically diffuse cluster magnetic fields (CMFs) – and how they relate to the thermodynamic nature of the ICM remains elusive. Filling this gap in knowledge is vital because clusters help us constrain cosmological parameters [2], develop hierarchical structure formation models [3], and study the synergy of many physical processes to answer the question, "How does the Universe work?" [4].

At present, one of the biggest challenges in cluster studies is explaining the relative thermal equilibrium of the ICM. Many clusters have core ICM cooling times much less than a Hubble time, and it was hypothesized that these systems should host prodigious "cooling flows" [5]. But, only minimal mass deposition rates and cooling by-products have ever been detected, requiring that the ICM be heated [6]. Observational and theoretical studies have strongly implicated feedback from active galactic nuclei (AGN) in supplying the *energy* needed to regulate ICM cooling and late-time galaxy growth [7]. However, precisely how AGN feedback energy is thermalized and which processes comprise a complete AGN feedback loop remain to be fully understood [8].

Theoretical studies are now focused on coupling AGN feedback and ICM heating using combinations of anisotropic thermal conduction, cosmic ray diffusion, and subsonic turbulence [*e.g.* 9–17] after observations suggested the ICM is turbulent and conducting on small scales [*e.g.* 18–20]. These microphysical processes are intrinsically linked to macroscopic CMF topologies through gas viscosity and magnetohydrodynamic (MHD) instabilities [21, 22]. Thus, to observationally test and refine this theoretical framework, it is ideal to have uniform measurements of CMF strengths, orientations, and spatial distributions for large cluster samples spanning a broad range of evolutionary & dynamical states. Unfortunately, CMFs must be indirectly observed through steep spectrum, non-thermal synchrotron emission best detected at low radio frequencies [$\lesssim 2$ GHz; 23]. A robust census of CMFs has been lacking because of limitations in the sensitivity and resolution of past radio measurements [*e.g.* 24], limiting our knowledge of CMF demographics to a few clusters [*e.g.* 25]. Additionally, this shortfall has inhibited the study of CMF origins and dynamical importance [26].

The greatly improved capabilities of NRAO's Expanded Very Large Array (*EVLA*) will significantly impact this field by bringing powerful radio CMF survey and polarization capabilities through unprecedented sensitivity, resolution, and frequency coverage [27]. **As an Grainger fellow, I propose to use radio polarimetry in conjunction with X-ray & optical imaging to map CMFs (magnitudes, orientations, 3D structure) and evaluate their relationship with ICM thermal properties (*e.g.* temperature, entropy, pressure) to constrain which physical mechanisms are responsible for the qualitative differences between observed and theoretical CMFs.** This work will 1) determine which microphysical processes significantly contribute to heating of the ICM by directly comparing the predictions of theoretical models with CMF observations, and 2) place constraints on the origin of CMFs and the cosmological implications of non-thermal pressure support on cluster mass estimates. The proposed project includes plans for an *EVLA* radio survey and NOAO optical Hα survey of two well-studied cluster samples, and incorporates an on-going pipeline analysis of an archive-limited sample of clusters having X-ray data.

II. Observations and Analysis

The *EVLA* Polarimetry Cluster Survey (EPiCS) will target the flux-limited HIFLUGCS [28] and representative REXCESS [29] cluster samples for which uniform *Chandra* and *XMM-Newton* X-ray data is available. EPiCS will utilize *EVLA*'s increased polarimetry bandwidth (8 GHz per polarization) and frequency accessibility (74

MHz; 330 MHz; full coverage 1–2 GHz) to obtain deep ($\sigma_{\rm rms} < 10\ \mu$Jy beam^{-1}) full Stokes observations of each cluster. The improved *EVLA* efficiency and dynamic range mean extended sources as faint as ∼2-3 μJy will be detected with integration times $\lesssim$ 5 hrs, well into the regime where μG CMFs excite emission. One of *EVLA*'s two low-frequency (< 0.5 GHz) systems is now functioning, and EPiCS will be cross-calibrated with data from *LOFAR* to expand the utility of the dataset. EPiCS observations are designed to enable measurements of: 1) CMF strengths using Faraday rotation measures (RM) of previously undetected embedded & background cluster radio sources [see Fig. 1 and 30 for method], 2) large-scale CMF orientations using coherent polarized emission of orbiting cluster member galaxies [see Fig. 2 and 31 for method], and 3) CMF spatial distributions & ordering using low-surface brightness emission of radio halos [see 32 for method]. Combined with the archival X-ray data for each source, the following outstanding issues will be investigated.

A. Testing Models of ICM Heating: The EPiCS campaign will produce data of sufficient quality to measure RM dispersions, estimate CMF radial amplitude profiles, directly reconstruct CMF power spectra, and model 3D CMF structure using RM synthesis [see methods in 33–35]. Each of these CMF diagnostics will be directly compared with results from MHD models in the literature (see Fig. 3 for example) to determine which predictions are replicated (*e.g.* preferentially radial CMFs, CMF profile shapes, CMF magnitude–ICM $n_{\rm e}$ & $kT_{\rm X}$ correlations), which predictions indicate the input physics may be incomplete, and to help constrain which microphysical processes might participate in ICM heating. Since AGN feedback is the likely progenitor of heating, an investigation of possible correlations between CMF properties and feedback signatures (*e.g.* cluster core entropy, jet powers for systems with cavities, 2D thermal distributions, extent of central AGN activity) will be undertaken. Further, turbulence is considered vital for promoting ICM heating, but is difficult to directly measure. However, secondary diagnostics (*e.g.* AGN outflows, mergers, cold fronts, shocks) may indicate the presence of turbulence even when the data is insufficient to do so. These indicators will be considered during the analysis to check if trends exist with CMF properties.

B. CMFs in Cluster Cores: It is hypothesized that the Hα filaments seen in almost all cool core clusters provide a local measure of CMF strength and orientation since they may form along field lines and be excited by some combination of turbulent mixing and conduction [36, 37]. To probe CMF configurations and conductive heating on kpc scales, below the reach of the radio observations, a uniform optical survey for extended Hα filaments in the EPiCS cluster samples will be undertaken using new NOAO instruments (*i.e.* Magellan Maryland Tunable Filter, WIYN HiRes IR Camera, SOAR Spartan IR Camera) [see 38, for method]. The observations will allow, for the first time, a complete characterization of filament morphologies and energetics to be compared with uniform ICM and CMF properties for the same objects. These observations will confront model predictions by answering the question, "Are filament energetics and morphologies consistent with them being magnetic structures conductively heated by the ICM?" Combined with the radio-derived CMF properties, inferences will also be drawn about if, and possibly how, large- and small-scale CMF properties are related (*e.g.* the coherence length). The model comparisons from Section A will also answer the questions: do filaments thrive in low-turbulence, high-magnetic field strength environs? Does this imply MHD instabilities are suppressed or inactive in some cluster cores?

C. Constraining CMF Origins and Non-thermal Pressure Support: Simply put, where do CMFs come from (*e.g.* amplified primordial cosmic field? the Biermann battery process? AGN/galactic outflow seeding of protoclusters?), and are they dynamically important [39]? The EPiCS project will help address these questions. As the quantities most closely related to dynamo-driven CMF formation, I will investigate how redshift, halo concentration, and cluster mass relate to the derived CMF power spectra and radial profiles [40]. At a minimum, these comparisons will place limits on the strength and distribution of allowable seed field models, and may possibly suggest whether early- or late-time amplification processes dominate [41]. Deriving halo concentrations and cluster masses follow directly from the X-ray analysis already in-hand. However, cluster masses are traditionally derived by assuming the ICM is in hydrostatic equilibrium. If CMFs provide significant ICM pressure support, then cluster masses may be systematically overestimated, having interesting repercussions on cluster cosmological studies. Thus, cluster masses and the cluster mass function will be recalculated [*e.g.* 42] including terms for CMF pressure support determined from the EPiCS measurements. How cosmological parameter uncertainties depend on CMFs will then be determined. This exercise will be particularly interesting for the REXCESS sample which has high-quality hydrostatic mass estimates [43].

D. Archival Project and Legacy: Work has started on archival *Chandra* and *VLA* data to build the infrastructure needed to maximize the ultimate scientific impact of this project and produce initial results for an archive-limited sample of clusters. There are ≈ 450 clusters which have archival *Chandra* (≈ 900 observations) and *VLA* (≈ 1000 observations) data. Of these, 325 clusters have had the X-ray data reduced using an extensible and mature pipeline, while 50 of those clusters have had the multifrequency radio data reduced. The X-ray results are being kept in a public database[1] while the radio analysis continues. The on-going analysis entails production of 2D ICM temperature, density, pressure, & entropy maps, more radial profiles (*e.g.* effective conductivity, implied suppression factors), and refinement of the radio reduction pipeline. Mitigation of radio frequency interference (RFI) is a lengthy and tedious step in radio analysis. To alleviate this tension, a portable Python version of the 'RfiX' rejection algorithm [44] has been written and is being tested. To widen this proposal's scientific impact and relevance to future radio observatories (*e.g. LOFAR*, *LWA*, *SKA*), all code, software, and results will be made freely available to the research community. The results from this project will also serve as science drivers for future *EVLA* upgrades, *i.e.* Low Frequency System (full 50–1000 MHz) & ultracompact E-array [45], being proposed specifically to study cosmic magnetism.

III. References

[**1**] Sarazin. *RvMP*, 58:1, Jan. 1986.
[**2**] Voit. *RvMP*, 77:207, Apr. 2005.
[**3**] Navarro et al. *MNRAS*, 275:56, Jul. 1995.
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[**6**] Peterson & Fabian. *Phys. Rep.*, 427:1, Apr. 2006.
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[**8**] De Young. *ApJ*, 710:743, Feb. 2010.
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[**10**] Voit et al. *ApJ*, 681:L5, Jul. 2008.
[**11**] Guo et al. *ApJ*, 688:859, Dec. 2008.
[**12**] Sharma et al. *ApJ*, 699:348, Jul. 2009.
[**13**] Bogdanović et al. *ApJ*, 704:211, Oct. 2009.
[**14**] Parrish et al. *ApJ*, 712:L194, Apr. 2010.
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[**16**] Kunz et al. *arXiv:1003.2719*, Mar. 2010.
[**17**] Ruszkowski et al. *arXiv:1010.2277*, Oct. 2010.
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[**19**] Cavagnolo et al. *ApJ*, 683:L107, Aug. 2008.
[**20**] Million et al. *MNRAS*, 407:2046, Oct. 2010.
[**21**] Balbus. *ApJ*, 534:420, May 2000.
[**22**] Quataert. *ApJ*, 673:758, Feb. 2008.
[**23**] Ferrari et al. *SSRv*, 134:93, Feb. 2008.
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[**25**] Govoni et al. *arXiv:1007.5207*, Jul. 2010.
[**26**] Grasso & Rubinstein. *Phys. Rep.*, 348:163, Jul. 2001.
[**27**] Perley et al. *IEEE Proceedings*, 97:1448, Aug. 2009.
[**28**] Reiprich. Ph.D. thesis, Jul. 2001.
[**29**] Böhringer et al. *A&A*, 469:363, Jul. 2007.
[**30**] Bonafede et al. *A&A*, 513:A30+, Apr. 2010.
[**31**] Pfrommer & Dursi. *NatPh*, 6:520, Jul. 2010.
[**32**] Keshet & Loeb. *ApJ*, 722:737, Oct. 2010.
[**33**] Vogt & Enßlin. *A&A*, 412:373, Dec. 2003.
[**34**] Murgia et al. *A&A*, 424:429, Sept. 2004.
[**35**] Brentjens & de Bruyn. *A&A*, 441:1217, Oct. 2005.
[**36**] Sharma et al. *ApJ*, 720:652, Sept. 2010.
[**37**] Werner et al. *MNRAS*, 407:2063, Oct. 2010.
[**38**] McDonald et al. *ApJ*, 721:1262, Oct. 2010.
[**39**] Carilli & Taylor. *ARA&A*, 40:319, 2002.
[**40**] Donnert et al. *MNRAS*, 392:1008, Jan. 2009.
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[**42**] Vikhlinin et al. *ApJ*, 692:1060, Feb. 2009.
[**43**] Arnaud et al. *A&A*, 517:A92+, Jul. 2010.
[**44**] Athreya. *ApJ*, 696:885, May 2009.
[**45**] Ott et al. *"Pushing the Limits of the EVLA,"* 2010.

[1] http://www.pa.msu.edu/astro/MC2/accept/

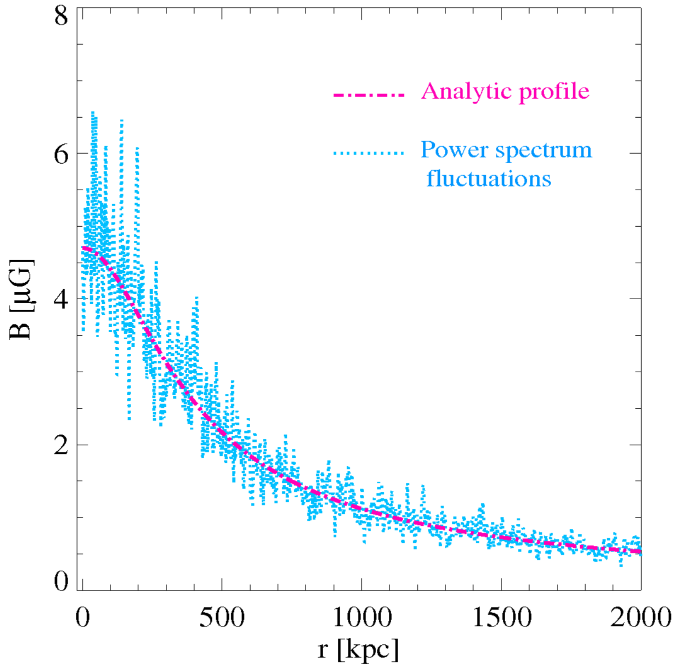
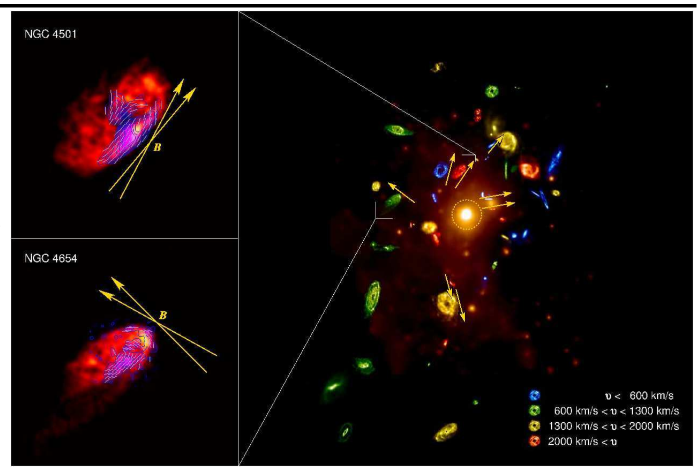


Figure 1: Radial profile and power spectrum of the Coma CMF derived from 3D simulations which reproduce observed RMs of embedded and background radio sources (taken from Bonafede et al. 2010 [29]). If one assumes the CMF and ICM thermal radial distributions trace each, then comparison of observed RM dispersions and 3D simulations lead to constraints like this on the CMF profile without the need to make measurements at every radius. One goal of this proposal is to expand upon the Bonafede et al. result using a larger cluster sample and EVLA observations.

Figure 2: Virgo CMF orientations (yellow arrows) taken from Pfrommer & Dursi 2010 [30] where they argue draping of CMF lines at the ICM-infalling galaxy interface explains the CPE (left panel at 5 GHz). The CPE results from galactic cosmic rays gyrating around regularly compressed field lines. The authors argue the Virgo CMF is preferentially radial, consistent with the effects of a large-scale MHD convective instability [*i.e.* the MTI; 21]. Similar measurements are a key feature of the EPiCS project and will help us constrain CMF orientations as never before.



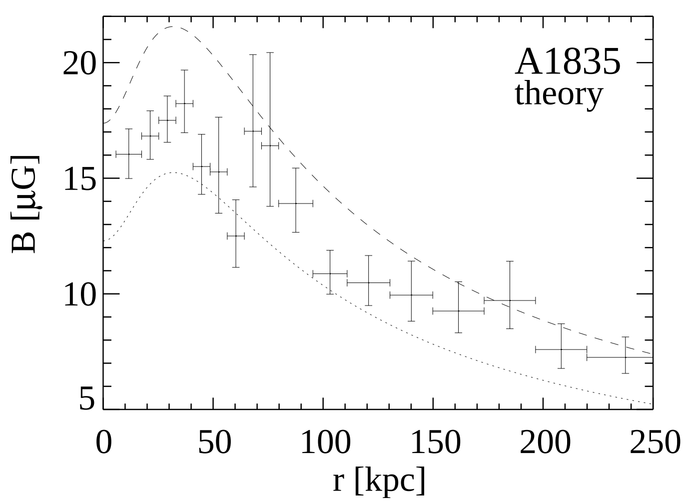


Figure 3: Predicted CMF strength of Abell 1835 from model of Kunz et al. 2010 [16] which heats the ICM *only* via viscous dissipation of turbulent ICM motions. The Kunz et al. model takes in X-ray derived ICM density and temperature measurements alone and returns estimates of field strengths. These profiles have already been derived for over 300 clusters using the *Chandra* archival project, and will be compared with the results of the EPiCS program (*e.g.* radial profiles and power spectra, like Fig. 1) to test how important turbulent heating is for an array of cluster types. This is one example of how the proposed CMF measurements will be directly compared with model predictions to aide theorists in refining models for ICM heating.