First result from eROSITA and synergies with CMB-S4

Vittorio Ghirardini
eROSITA on SRG

- 7 mirrors and 7 pnCCD
- Sensitive from 0.2 keV to 10 keV X-ray band
- Spectral resolution: 75-82 eV FWHM at 1.49 keV
- Focal length 1.6m
- FoV 1 deg diameter
- HEW 18″ on-axis, 26″ FoV avg.
- Baffles 92% reduction straight light
eROSITA advantages for clusters

Moon diameter
30 arcmin

XMM-Newton
Field of view ~ 30 arcmin

Chandra
Field of view ~ 17 arcmin

Credit: M. Ramos-Ceja

eROSITA
Field of view ~ 65 arcmin

+ Scanning feature

Grasp; FOV*Effective Area @1keV:
- 5×XMM-Newton
- 100×Chandra ACIS
Cluster Astrophysics and Cosmology with eROSITA

Cosmology

- Map of dark energy (new physics?)
- Nature of dark matter (WIMP, pBH, ...)
- Inhomogeneity of the Universe
- Baryon evolution

Dark Matter

WHIM

- Chemical enrichment
- Missing baryons
- AGN feedback
- Physics of hot diffuse plasma
- WHIM

Baryon evolution

CMB-S4 collaboration meeting 12/8/2021
Cal-PV program

A3158 - Whelan+21

A3408 - Iljenkarevic+21
(AGN 1H0707-495)

A3266 - Sanders+21

A3391/95 - Reiprich+21 - Bifi+21 - Veronica+21

CMB-S4 collaboration meeting 12/8/2021
Exposure corrected image in the 0.5–2.0 keV band
- Proof of concept at final survey depth
- ~540 extended sources detected
- Mass down to $10^{13} M_\odot$
- Redshift up to 1.3
- Complete Coverage with HSC, GAMA, DeCALS
- Dedicated SDSS-IV and V plates
- Radio follow-up with LOFAR and uGMRT
- Dedicated NIKA2 and XMM-Newton observation

Exposure corrected image in the 0.5–2.0 keV band
eFEDS clusters

CMB-S4 collaboration meeting 12/8/2021 V. Ghirardini 8 / 23
• 19 superclusters Y. Özsoy
Selection Function using dedicated simulations

Credit: N. Clerc
Scaling relation and selection effects

- Comparison of WL Selection with X-rays

Ramos+21
Morphological parameters

Disturbed

Relaxed

Ghirardini+21
Cluster Mass Calibration

\[ L_X = \left( \frac{M_{500}}{M_{500}^{\text{pivot}}} \right)^{\frac{3}{2}} \left( \frac{1 + z}{1 + z_{\text{pivot}}} \right)^{\frac{3}{2}} \left( \frac{E(z)}{E(z_{\text{pivot}})} \right) \left( 1 + z \right)^{\frac{3}{2}} \]

Chiu+21
eROSITA First All-Sky Survey (eRASS1)
eRASS1 groups and clusters

- >11k sources
- Optimized cleaning (split and overlapping sources)
- Matches:
  - SPT: 255 clusters
  - ACT: 845 clusters
  - MCXC: 561 clusters

Credit: E. Bulbul
Synergies with CMB-S4

- Thermodynamical Properties of the ICM out to $R_{200}$
  - Eckert+13, Ghirardini+19

\[ \epsilon_X \propto \int n_e n_i \Lambda_c(T_e, Z) \, dl \Rightarrow \langle n_e \rangle \]

\[ \epsilon_{SZ} \propto \int n_e T_e \, dl \Rightarrow \langle P_e \rangle \]

- Temperature $P_e/n_e$
- Entropy $T_e n_e^{-2/3}$
- Hydrostatic Mass $M(< R) \propto n_e^{-1} dP_e/dR$
- Polytropic Index $P_e \propto n_e^\Gamma$
• Evolution of thermodynamic properties

Ghirardini+20, McDonald+14+17, Sanders+17

Credit: McDonald+17
Synergies with CMB-S4

- Population studies (selection effects)
  Lovisari+17, Rossetti+17, Nurgaliev+17, Ramos+21

Credit: Rossetti+17
Synergies with CMB-S4

• $H_0$ measurement

Bonamente+06, Kozmanyan+19

\[
\epsilon_X \propto n_e n_l \Lambda_c(T_e, Z) d_A
\]

\[
\epsilon_{SZ} \propto n_e T_e d_A
\]

\[
\Rightarrow \frac{\epsilon_{SZ}^2}{\epsilon_X} \propto T_e^{3/2} d_A \propto T_e^{3/2} H_0^{-1}
\]
• In eFEDS we detect $>4$ clusters per deg$^2$, as expected
• $M > 10^{13} M_\odot$, $z < 1.3$
• Contact our working groups

https://www.mpe.mpg.de/455860/working_groups

• Liu+21 Clusters and group catalog
• Ghirardini+21 Morphological properties
• Klein+21 Optical properties
• Bahar+21 Scaling relations
• Ramos+21 X-ray properties of HSC selected sample
• Chiu+21 Weak lensing mass calibration
• Pasini+21 Radio properties
• and more ...
X-ray luminosity function

![Graph showing the X-ray luminosity function with different data points and lines representing various regions of luminosity.]
Cluster Mass Calibration

- Optical Data through richness vs. mass scaling relations
- X-ray observations through hydrostatic equl. assumption
- Weak Lensing (DES, KIDS, and HSC)