INSERT CREATIVE NAME HERE

Author's name

Bachelorarbeit in Physik
angefertigt im Argelander-Institut für Astronomie

vorgelegt der
Mathematisch-Naturwissenschaftlichen Fakultät
der
Rheinischen Friedrich-Wilhelms-Universität
Bonn

MMM 2024

Ich versichere, dass ich diese Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt sowie die Zitate kenntlich gemacht habe.

Bonn, ...

Datum Unterschrift

1. Gutachter: Prof. Dr. John Smith
2. Gutachterin: Prof. Dr. Anne Jones

Acknowledgements

I would like to thank ...

You should probably use `\chapter*` for acknowledgements at the beginning of a thesis and `\chapter` for the end.

Contents

CHAPTER 1

Introduction

Testing Kolokythas et al., 2020. new line

CHAPTER 2

Theoretical Background

2.1 Clusters and groups of galaxies

Throughout the Universe, galaxies are not distributed homogeneously but are instead aggregated into massive cosmic structures known as galaxy groups or galaxy clusters. Galaxy clusters – the largest relaxed structures in the Universe – typically have masses exceeding $M \gtrsim 3 \times 10^{14} M_{\odot}$, whereas galaxy groups have masses around $M \sim 3 \times 10^{13} M_{\odot}$ (Schneider, 2006). Advancements in X-ray astronomy have demonstrated that these structures are significant sources of X-ray radiation (Cavaliere, Gurksy, and Tucker, 1971). This emission is well understood to originate from a hot intergalactic gas known as the intracluster medium (ICM), which is characterized by temperatures in the range of 10^7 to 10^8 K and constitutes the primary baryonic component of galaxy clusters (Schneider, 2006).

2.1.1 The Intracluster Medium (ICM)

Within the deep gravitational wells of galaxy clusters, the temperatures become sufficiently high to fully ionize lighter elements and partially ionize heavier elements, resulting in the formation of a plasma. This hot, diffuse, and optically thin plasma, known as the Intracluster Medium (ICM), emits significant amounts of X-ray radiation. X-ray analysis of the ICM have enabled a wide variety of cosmological studies, including large-scale structure formation in the Universe (Kravtsov and Borgani, 2012).

2.1.2 Emission Processes within the ICM

A key principle of electrodynamics is that accelerated charges radiate energy. This radiation is referred to as bremsstrahlung or "free-free" when a free charged particle, typically an electron, is accelerated by the electric field of other charges, usually ions. In the ICM, this process predominates at temperatures above $k_B T_e \gtrsim 2\,\mathrm{keV}$, where the total emissivity at solar metallicity scales approximately as

$$\epsilon_{\mathrm{ff}} \propto T_e^{\frac{1}{2}} n_e,$$

with n_e and T_e as the electron number density and temperature, respectively. At lower temperatures ($k_B T \lesssim 2\,\mathrm{keV}$), line emission becomes significant, with the emissivity being roughly described by

$$\epsilon \propto T_\mathrm{e}^{-0.6} n_\mathrm{e}.$$

2.1.3 The galaxy group NGC1550

Insert cool stuff about cluster here

2.2 eROSITA

The extended ROentgen Survey with an Imaging Telescope Array (eROSITA) is a highly sensitive, wide-field X-ray telescope designed to capture deep and precise images across large areas of the sky. Mounted on the Spektrum-Roentgen-Gamma (SRG) observatory in a halo orbit around the second Lagrange Point, eROSITA operates within the 0.2 to 10.0 keV energy range. It is the first instrument to perform an all-sky imaging survey in the hard X-ray band (2.0 to 10.0 keV). In the soft X-ray band (0.5 to 2.0 keV), eROSITA boasts a sensitivity that is approximately 20 times greater than that of its predecessor, the ROSAT All-Sky Survey. eROSITA features seven identical mirror modules, known as Telescope Modules (TMs), each with 54 mirror shells in Wolter-I geometry and a 1.6-meter focal length. Five TMs (TM1, TM2, TM3, TM4, TM6) have aluminum on-chip optical light filters and are collectively referred to as TM8. The remaining two TMs (TM5, TM7), designed for low-energy spectroscopy, lack these filters and are referred to as TM9. (Predehl et al., 2021)

2.3 Skybackground and contamination sources

For a thorough analysis of X-ray photons, it is essential to carefully consider both external contamination and internal instrumental distortion effects. The following section will provide a brief overview of the most important factors.

X-ray Background (XRB): The X-ray background consists of multiple sources, including diffuse emissions from the Local Hot Bubble and the Galactic halo Galeazzi et al., 2006, as well as discrete extragalactic sources, predominantly AGNs Brandt and Hasinger, 2005.

Particle Induced Background (PIB)

CHAPTER 3

Data Reduction

Bibliography

Brandt, W. and G. Hasinger (2005), *Deep Extragalactic X-ray Surveys*, Annual Review of Astronomy and Astrophysics **43** 827, First published online as a Review in Advance on June 14, 2005 (cit. on p. 3).

Cavaliere, A. G., H. Gurksy, and W. H. Tucker (1971), *Extragalactic X-ray Sources and Associations of Galaxies*, Nature **231** 437, ISSN: 1476-4687, URL: `https://doi.org/10.1038/231437a0` (cit. on p. 2).

Galeazzi, M., A. Gupta, K. Covey, and E. Ursino (2006), *XMM-Newton observations of the diffuse X-ray background*, Department of Physics, University of Miami (cit. on p. 3).

Kolokythas, K. et al. (2020), *Evidence of AGN feedback and sloshing in the X-ray luminous NGC 1550 galaxy group*, Monthly Notices of the Royal Astronomical Society **496** 1471, ISSN: 1365-2966, URL: `http://dx.doi.org/10.1093/mnras/staa1506` (cit. on p. 1).

Kravtsov, A. V. and S. Borgani (2012), *Formation of Galaxy Clusters*, Annual Review of Astronomy and Astrophysics **50** 353, ISSN: 0066-4146, eprint: `https://www.annualreviews.org/doi/pdf/10.1146/annurev-astro-081811-125502`, URL: `https://www.annualreviews.org/doi/10.1146/annurev-astro-081811-125502` (cit. on p. 2).

Predehl, P. et al. (2021), *First science highlights from SRG/eROSITA: The eROSITA X-ray telescope on SRG*, A&A **647** A1 (cit. on p. 3).

Schneider, P. (2006), *Extragalactic Astronomy and Cosmology: An Introduction*, Second Edition, Springer-Verlag Berlin Heidelberg 2006, ISBN: 978-3-642-54082-0 (cit. on p. 2).

List of Figures

List of Tables