Early-Type Galaxies: Automated Reduction and Analysis of ROSAT PSPC Data

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Abstract. We present initial results of early-type galaxies that will be part of a galaxy catalogue (XGALCAT) to be derived from the complete ROSAT archive. The archive data is reduced and analysed via an automatic pipeline that has been developed by the authors.

1. Introduction

The pipeline is based on an IRAF Command Language (CL) script, that consists of modules comprising IRAF and PROS tasks. The important features of the pipeline include new data time screening in order to maximize the signal to noise (SNR) ratio of faint point-like sources (see Bocchino et al., this conference), source detection via a wavelet algorithm (see Damiani et al., this conference), identification of sources (via SQL scripts and IRAF table tasks) with objects from existing optical, radio, infrared and X-ray catalogues, corresponding optical images from the STScI CD-ROM Digitized Sky Survey, and estimation of the source extent via wavelet source output and PSF comparison. The pipeline output includes reduced images, contour maps, surface brightness profiles (for extended sources), spectra, color and hardness ratios as well as data files ready for ingestion into a SYBASE Database.

2. Status of XGALCAT; Comparison with IPC fluxes

The pipeline has been run on 35 PSPC sequences with $T_{exp} > 15$ ksec. The following will present fluxes for 31 detections and 4 upper limits for galaxies that have accurate distances, un-confused X-ray fluxes, and unique object identifications. A comparison of our ROSAT PSPC fluxes with that of *Einstein* IPC fluxes from Fabbiano, Kim and Trinchieri (1992) (hereafter FKT) shows good agreement.

3. The L_X-L_B diagram

Figure 1 shows the new L_X-L_B diagram for E and S0 galaxies of 31 detections and 4 upper limits. Distances are from the Nearby Galaxies Catalog (Tully 1988) for galaxies with v < 3000 km/s, whilst other distances are derived from de Vaucouleurs et al. 1991 (hereafter RC3) velocities; all assume $H_0 = 75$ km/s/Mpc. The new diagram expands the detected L_X range to 10^{38} erg s^{-1}, approximately one order of magnitude lower than FKT with the new detections of N1400 (Log L_X = 38.22) and N4464 (Log L_X = 38.29).

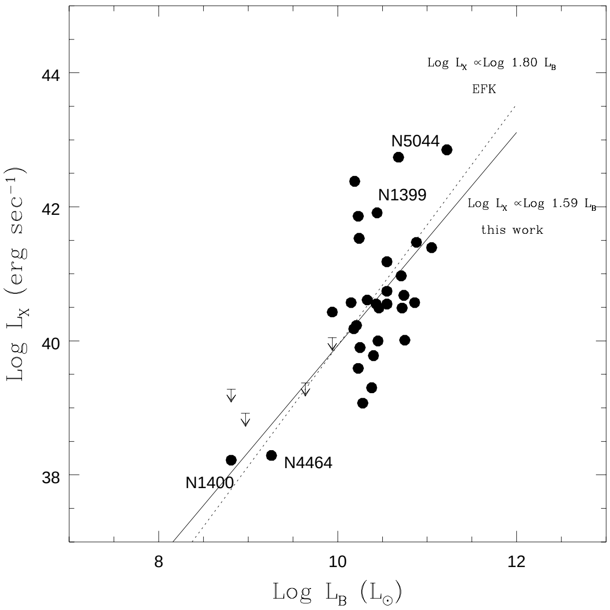

Fig. 1. ROSAT PSPC L_X-L_B diagram.

The regression fit for the PSPC data set is:

$$\text{Log } L_X = 1.59\pm0.31 \text{ Log } L_B + 24.03\pm3.18 \ (\sigma = 0.85)$$

which is in agreement with that found with *Einstein*, 1.8±0.1 (Eskridge, Fabbiano and Kim 1995). As well, both PSPC and *Einstein* regression slopes for Log $L_X < 40.5$, 1.15±0.23 and 1.0±0.2 respectively, are flatter, and consistent with the X-ray population of lower luminosity galaxies being directly proportional to their L_B.

4. XGALCAT X-ray colours

One of the aims of XGALCAT is to explore the spectral behaviour of E and S0s as a function of their physical and morphological properties. The pipeline output includes colour ratios defined as:

c21 = counts (0.61-1.11 keV) / counts (0.13-0.40 keV)

c32 = counts (1.19-1.97 keV) / counts (0.61-1.11 keV)

Figure 2 shows the colour-colour plane of early-type galaxies. Overlayed are diagnostic model colours for Raymond Smith thermal models of solar abundance for kT = 0.5, 1.0, 2.0 and 5.0 keV, and column densities $N_H = 10^{19}$, 10^{20} and 5.0×10^{21} cm^{-2}. Whilst a good fraction of galaxies are well represented by single temperature thermal models (0.7-1.3 keV) with line of sight N_H, it is clear that several have very soft (C21 < 1) colours. These may be similar to the low L_X/L_B (N4365 and N4382, Fabbiano et al. 1994) and the dynamically young Es (N3610 and N4125, Fabbiano and Schweizer 1995) that also display soft excesses.

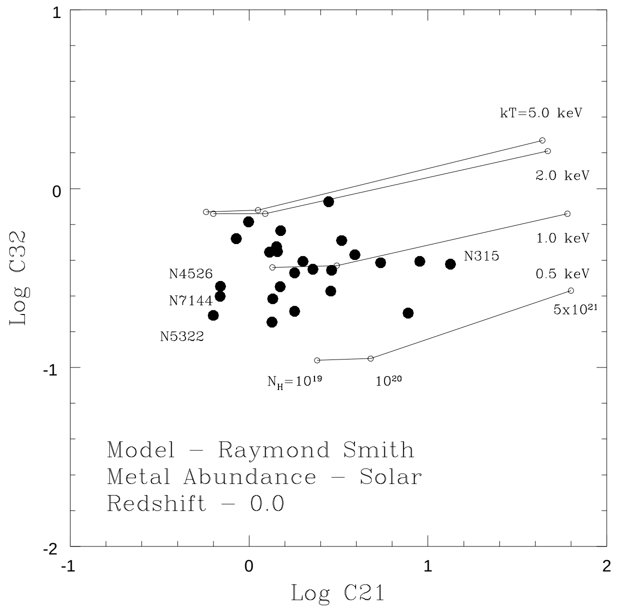

Fig. 2. C21 vs. C32 colours for early-type galaxies.

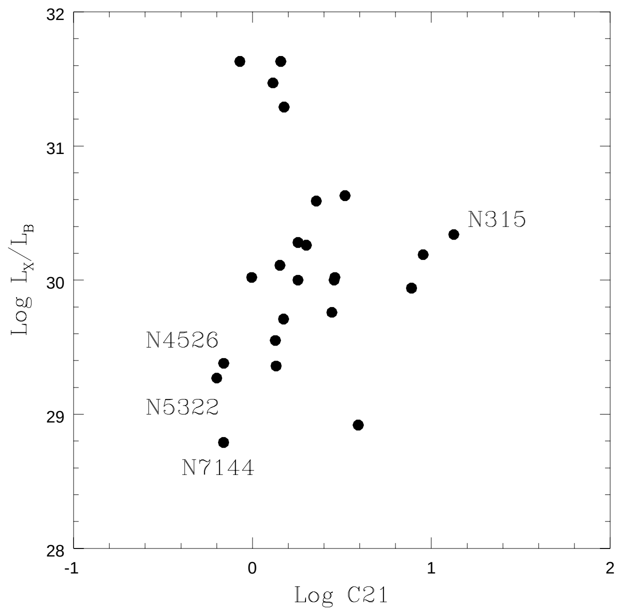

Fig. 3. C21 vs. Log L_X/L_B for early-type galaxies.

5. X-ray to Optical Ratio and X-ray colours

Figure 3 shows C21 colour vs. Log L_X/L_B. There is indeed an indication that the new soft C21 galaxies have low L_X/L_B ratios although there is considerable scatter. The small group of galaxies with soft Log C21 ($\sim$ 0-0.2) and high Log L_X/L_B (> 31.0) are central cluster galaxies. However, the three galaxies with the softest C21 colours (N4526 $S0_3$, N5322 E4 and N7144 E0) all have very low (< 29.4) Log L_X/L_B.

Interestingly, N5322 is listed in Schweizer et al. (1990) as having considerable fine structure (ie. ripples, jets, and other optical disturbances). Correlations between fine structure, optical colours and line strengths suggest that galaxies with significant fine structure may be young (< 7 Gyr) merger remnants. Is the X-ray soft excess then related to recent dynamical evolution? Are soft excesses only seen in low L_X/L_B objects that may have lost their hot gas halos?

6. XGALCAT: The Future

These initial results from XGALCAT suggest that substantial gains will be made in understanding the X-ray structural and spectral properties of early-type galaxies via a comprehensive and standardized analysis of ROSAT data.

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References

de Vaucouleurs et al. 1991, Third Reference Catalogue of Bright Galaxies (RC3)
Fabbiano, Kim and Trinchieri 1992, Ap.J. **80**, 531 (FKT)
Tully, 1988, Nearby Galaxies Catalog
Eskridge, Fabbiano and Kim 1995, Ap.J. Supp. **97**, 141
Fabbiano et al. 1994, ApJ, **429**, 94
Fabbiano and Schweizer 1995, Ap.J. **447**, 572
Schweizer et al. 1990, Ap.J. **364**, L33