The Nature of Elliptical Galaxies, Proceedings of the Second Stromlo Symposium, Eds. M. Arnaboldi, G.S. Da Costa & P. Saha

Environmental and internal optical properties and the X-ray content of E and S0s

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Abstract: We have compiled environmental (Tully 1988 ρ_{xyz}, local density; Schweizer et al. 1990 Σ, fine structure parameter) and internal (Trager et al. 1996 Lick group absorption indices) properties for E and S0s observed with *Einstein.* L_X/L_B is compared to all properties to determine their possible effect on gaseous X-ray content. Our main result is that the highest Σ galaxies (dynamically youngest) have very low L_X/L_B suggesting a suppression or decrease in L_X/L_B occurs for the youngest merger candidate galaxies. A general trend of lower L_X/L_B with increasing ρ_{xyz} is consistent with the results of White and Sarazin (1991). Little evidence of stellar population indicators being directly linked with L_X/L_B is seen. A trend for the highest Hβ galaxies (also having high Σ) to have low L_X/L_B is probably related to the association of young stellar populations with mergers or interactions.

1. Introduction

Determining the origin of scatter in the correlation between optical and X-ray luminosities of early-type galaxies will provide fundamental information about the evolution of both stellar and gaseous components. In this work we re-examine the X-ray properties of Es and S0s observed by *Einstein* by studying the behaviour of L_X/L_B with several optical environmental and internal properties. **Environmental** properties are provided by local galaxy densities as tabulated in Tully (1988). These will give an indication of the effect of processes, such as merging or interactions, have on hot gas halos. Also we list an optical structure parameter that measures recent merger activity or dynamical youth (Schweizer et al. 1990; Schweizer and Seitzer 1992), which gives us a direct indicator about the role of mergers on X-ray content. The **internal** properties are provided by absorption line indices of Trager et al. (1996). Since the origin of the hot gas is mass loss from evolving stars, we may expect to see trends between indices that directly measure evolved populations and L_X/L_B.

2. The Data

We have compiled optical data for 118 E and S0s observed by *Einstein*. To determine X-ray and optical luminosities we have used distances from Tully (1988) when listed, (H_0 = 75 km/s /Mpc). For 19 galaxies not in Tully (1988) we have assumed $D = v_{LG}/75.0$ Mpc, where $v_{LG} = v_{\odot} + 300 \sin l \cos b$. The *Einstein* flux data are taken primarily from Fabbiano, Kim and Trinchieri (1992). X-ray emission from Es and S0s will be a combination of discrete source and hot gas emission. If the X-ray discrete source contribution is directly proportional to L_B as expected from stellar population arguments then L_X/L_B will measure the prominence of hot gas emission.

3. The effect of local galaxy density on X-ray content

Figure 1(a) shows the behaviour of L_X/L_B against local galaxy density, ρ_{xyz}. L_X/L_B appears to be a complex function of ρ_{xyz} with large dispersion in L_X/L_B (factors of 100 and greater) especially at low (<2) values of ρ_{xyz}. A general trend of decreasing L_X/L_B with increasing ρ_{xyz} is seen however. There is an indication that low L_X/L_B galaxies (< 30.5) occur across a wider range of ρ_{xyz} than the higher L_X/L_B galaxies. This is consistent with the findings of White and Sarazin (1991) in which low L_X/L_B galaxies were preferentially found in higher density environments.

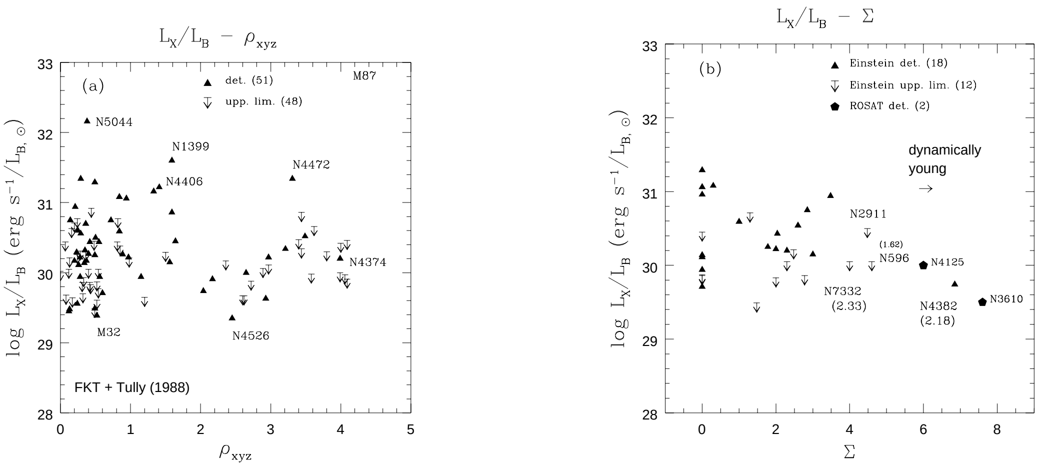

Figure 1(a). L_X/L_B versus local galaxy density, ρ_{xyz}. M87 (Fabricant and Gorenstein 1983) is also indicated. (b). L_X/L_B versus fine structure constant, Σ. Galaxies have $H\beta$ strengths indicated in brackets. The pentagons indicate ROSAT PSPC observed galaxies (N3610 and N4125; Fabbiano and Schweizer 1995).

4. The effect of dynamical youth on X-ray content

The behaviour between L_X/L_B and Σ is shown in Figure 1(b). Galaxies with low Σ span almost 2 orders of magnitude in L_X/L_B. However, galaxies with large Σ ($>$ 4) have low L_X/L_B. We have also indicated (via pentagons) two merger candidates N3610 and N4125 ($\Sigma = 7.60$ and 6.00 respectively) observed with ROSAT PSPC, that also have low L_X/L_B values (Fabbiano and Schweizer 1995). This behaviour suggests that a suppression or decrease in L_X/L_B occurs for the dynamically youngest galaxies. Since Bender et al. (1989) showed that high L_X Es tend to be optically boxy, we have checked the boxy/diskiness (a4/a) of the Σ >4 galaxies. Due to the small number of galaxies we cannot identify any strong trends in a4/a, yet, interestingly both NGC 596 ($\Sigma = 4.6$) and NGC 4382 ($\Sigma = 6.85$) show disky isophotes.

5. The effect of recent star formation on X-ray content

The relationship between young (nuclear) star populations and L_X/L_B is illustrated in Figure 2, where the strongest Hβ absorption galaxies also possess the lowest L_X/L_B values.

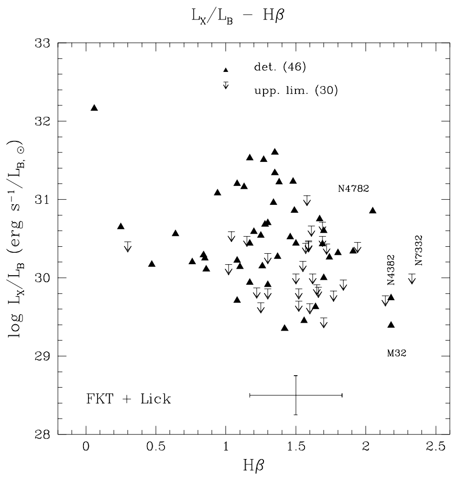

Figure 2. L_X/L_B versus Hβ for galaxies with 0< E.W. (Hβ) <2.5.

Since Schweizer et al. (1990) has shown that strong Hβ is associated with dynamically young galaxies, this trend may be expected, at least in part, due to the behaviour of L_X/L_B and Σ. In fact the link between high Σ and strong Hβ is shown in Figure 1(b) where $\Sigma >= 4$ galaxies have Hβ values (1.62, NGC 596; 2.33, NGC 7332 and 2.18, NGC 4382) listed. These galaxies are at the extreme end of the Hβ distribution. The large scatter in Figure 2 could be partially explained by different merger ages, types of progenitors, and gas contents, leading to various strengths of young star populations and hot gas contents. Matthews and Brighenti (these proceedings) investigate the evolution of hot gas due to mergers and conclude that the gas content may be stable or increase if merger induced star formation proceeds with a normal Salpeter IMF, or can decrease if the IMF favours more massive stars.

6. Other line indices

We have also searched for correlations between L_X/L_B and Mg_2/Fe5270, Na D and TiO_1. Peletier (1989) and Worthey et al. (1992) have shown an Mg excess (or Fe deficit) exists in the most optically luminous Es. This behaviour is also seen, with large scatter, between Mg_2/Fe5270 and L_X/L_B. and may support a selective loss mechanism (that preferentially retains Mg) in a galactic wind process as suggested by Worthey et al. (1992). Correlations between Na D or TiO_1 with L_X/L_B may suggest a direct link between the strength of the evolved stellar population and present epoch hot gas content, yet none were seen.

7. Conclusions

Our main result is that the highest Σ galaxies tend to have low L_X/L_B suggesting that hot gas is suppressed in dynamically young, and possibly major ($\sim$*equal mass* progenitor) mergers. This may not be at odds with high L_X galaxies being optically boxy (Bender et al. 1989), since if the boxiness is caused by *low mass* secondary mergers, then the different X-ray contents reflect two very different merger scenarios. A general trend of lower L_X/L_B with increasing ρ_{xyz} is consistent with the results of White and Sarazin (1991). L_X/L_B is also dependent on Hβ such that large Hβ galaxies have low L_X/L_B, consistent with the behaviour of L_X/L_B with Σ since star formation is commonly seen in dynamically young galaxies. No other line indices showed significant trends with L_X/L_B further suggesting that environmental factors play an important role in determining the hot gas content of early-type galaxies.

This work was supported by NASA grant NAGW-2681 (LTSA).

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