X-ray Emitting Galaxies in the SDSS

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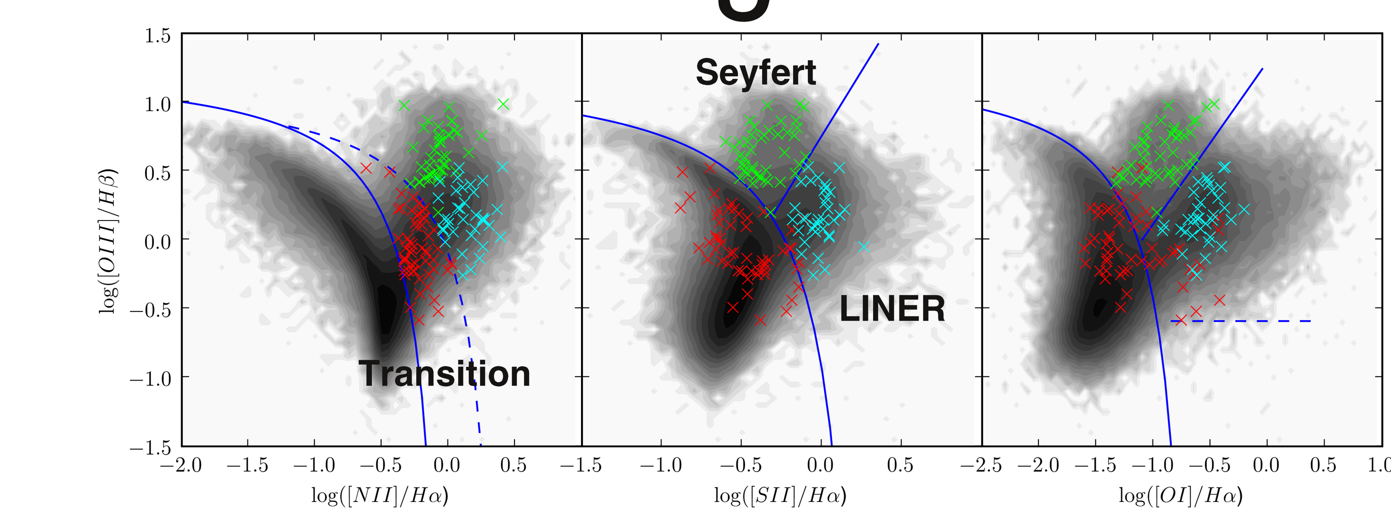
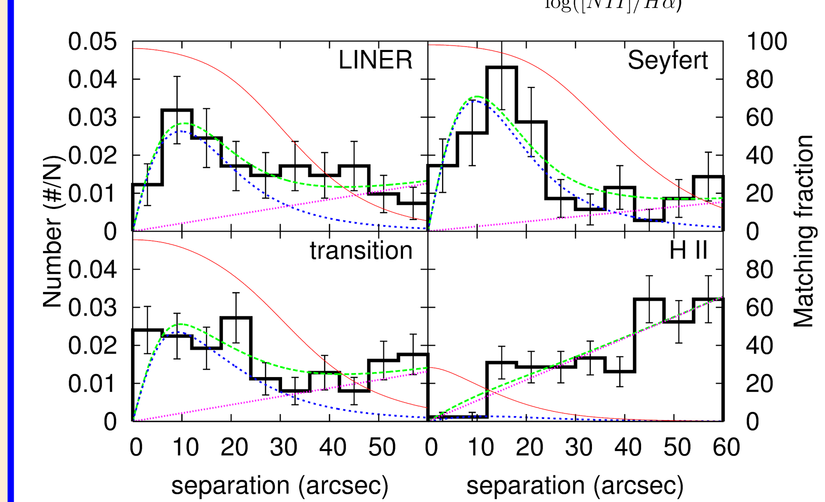
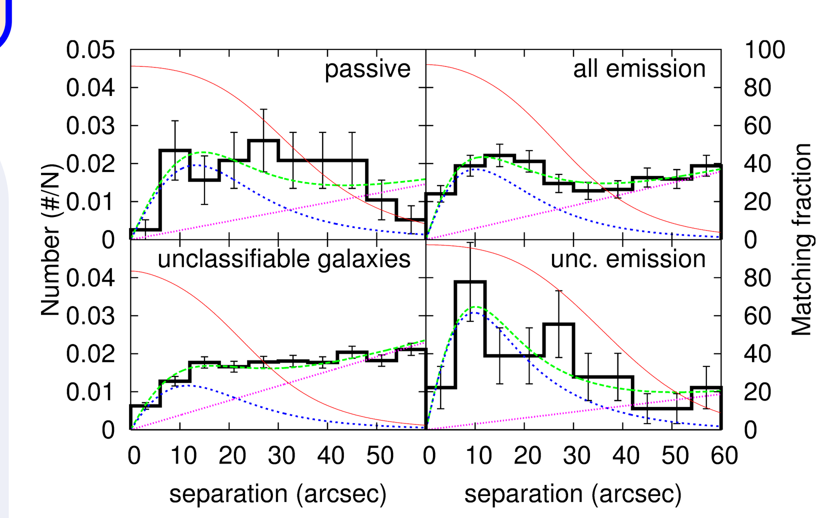
Matching the ROSAT All Sky Survey (RASS) and the SDSS results in many ambiguous matches. In a previous paper (Parejko et al., 2008) we described a method for statistically identifying likely matches between these surveys based on spectroscopic classification. The large sample size and spectroscopic uniformity of the SDSS allow us to systematically constrain the types of galaxies that are detected by RASS. We identify likely soft X-ray emitting galaxies in the SDSS, constructing a large, uniform sample of RASS-detected galaxies of various spectral types. We perform a 2-dimensional optical light profile reconstruction (point source+deVaucouleurs) on these galaxies to extract the AGN flux. For this sample we describe the emission-line to X-ray flux ratios and the relationship between the central point source and the X-ray emission. We find a variation in X-ray luminosity vs. optical emission-line slope between different spectral classes as well as weak trends in extracted AGN color vs. X-ray luminosity. We are also applying the matching method developed with SDSS to match other galaxy catalogs to RASS, thus constraining the RASS detection fraction for very nearby galaxies.

1. Background





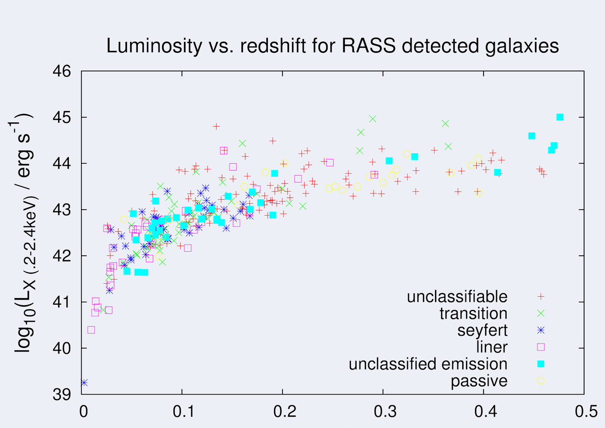


Galaxies possessing emission lines with >2σ detections are spectroscopically classified as Seyfert, LINER, Transition, H II or Unclassified by their location in three emission line flux ratio diagrams (Kewley et al. 2006). Passive galaxies have no detected emission lines while Unclassifiable galaxies have <2σ detections for one or more of the relevant lines. To the left we show histograms of the separation between the RASS and SDSS sources and simulated histograms grouped by spectral type. The simulated total histograms (green) are produced from a random match component (purple) and "simulated true match" component (blue). For details, see Parejko et al. (2008).

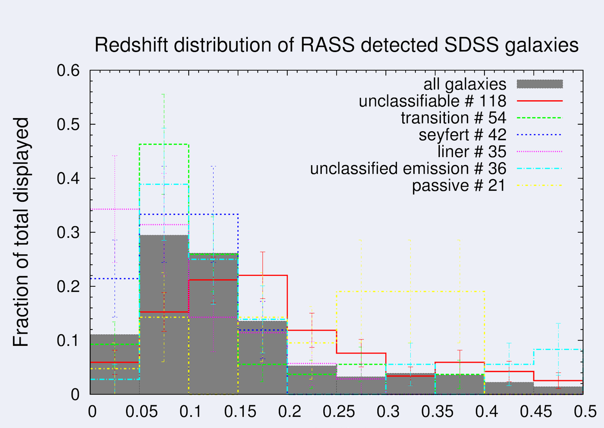
Note that the "true matching fraction" (true/total, red, using the right-hand axis.) is strongly dependent on spectroscopic classification. Galaxies with a strong AGN component have a high matching fraction out to relatively large radii, while essentially no H II galaxies are detected by RASS. This contrasts with spectroscopic surveys of RASS sources (e.g. Kollatschny et al., 2008) which claim to find H II galaxies with RASS detections. We are working on a systematic test to determine the RASS detection fractions for very low redshift galaxies (NGC, UGC, etc.) to reconcile these differences.

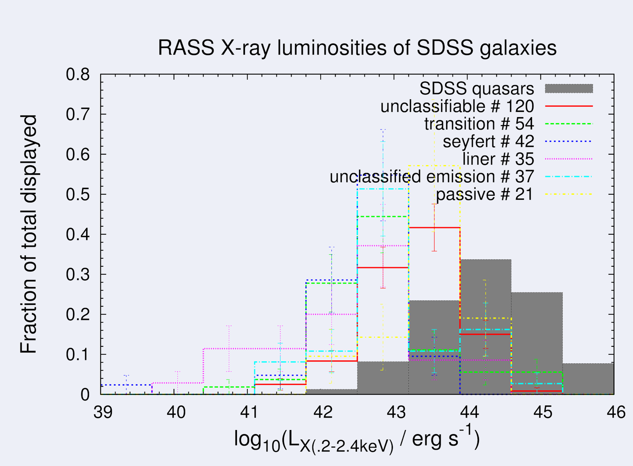
We consider here only galaxies with > 75% RASS matching fraction.

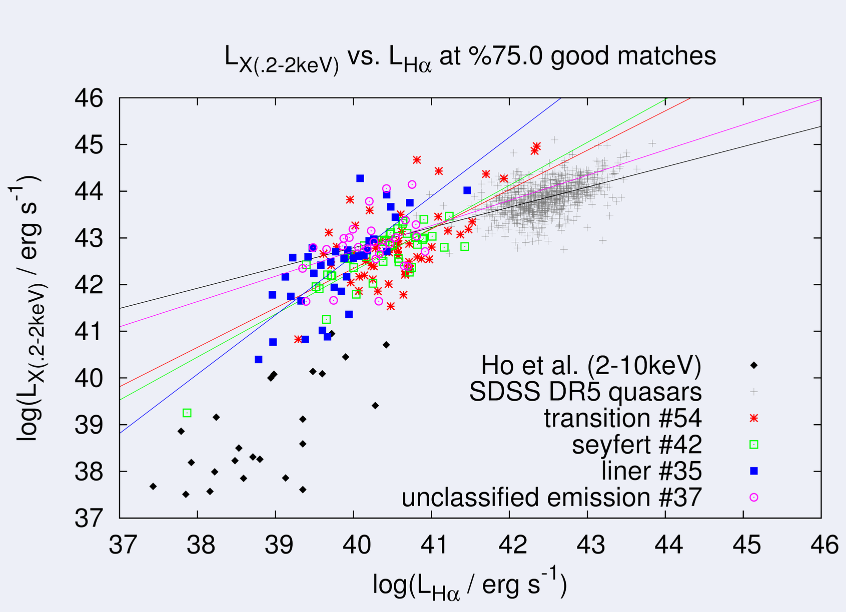
2. X-ray properties

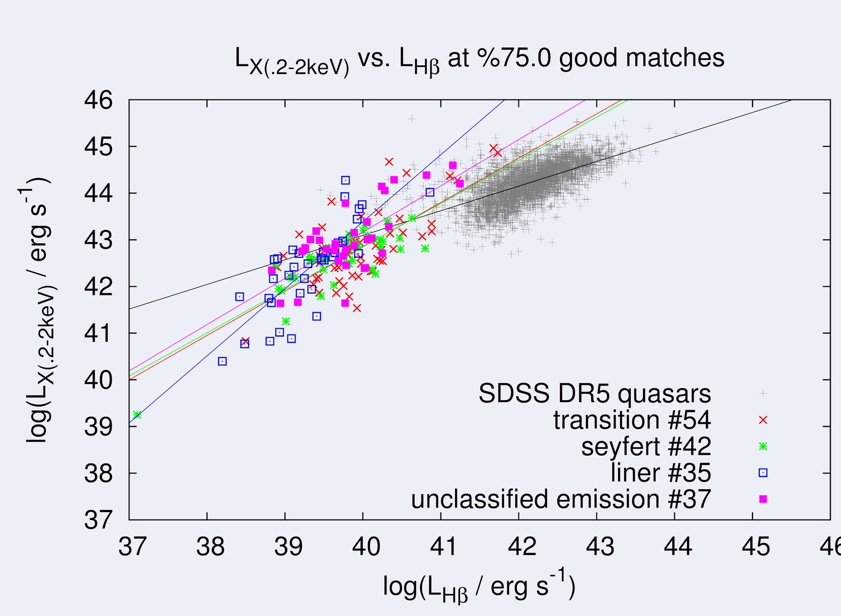


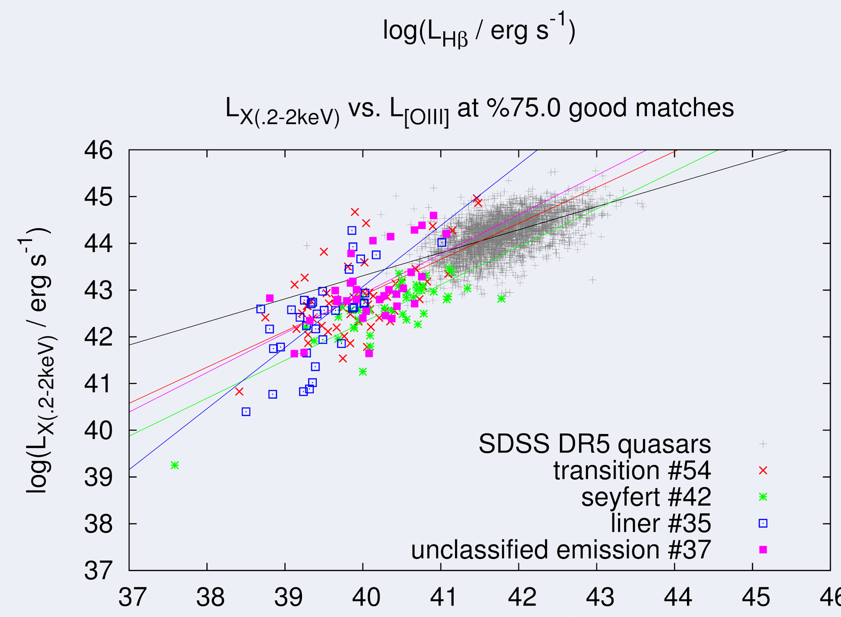
The luminosity/redshift distribution is due to a combination of selection effects, including the RASS flux limits, the r<17.77 SDSS spectroscopic galaxy selection and the emission-line detection limits (we require >2σ detections for each of the relevant lines). Passive galaxies have by far the highest mean redshifts of the sample, with many of them being drawn from the SDSS Large Red Galaxy (LRG) sample. This hints that the X-rays are coming from intra-cluster gas (see note in section 3). Seyfert galaxies show the lowest mean X-ray luminosity, with LINERs and Transitions showing ~3x higher luminosity, on average. RASS matched quasars are shown for reference.









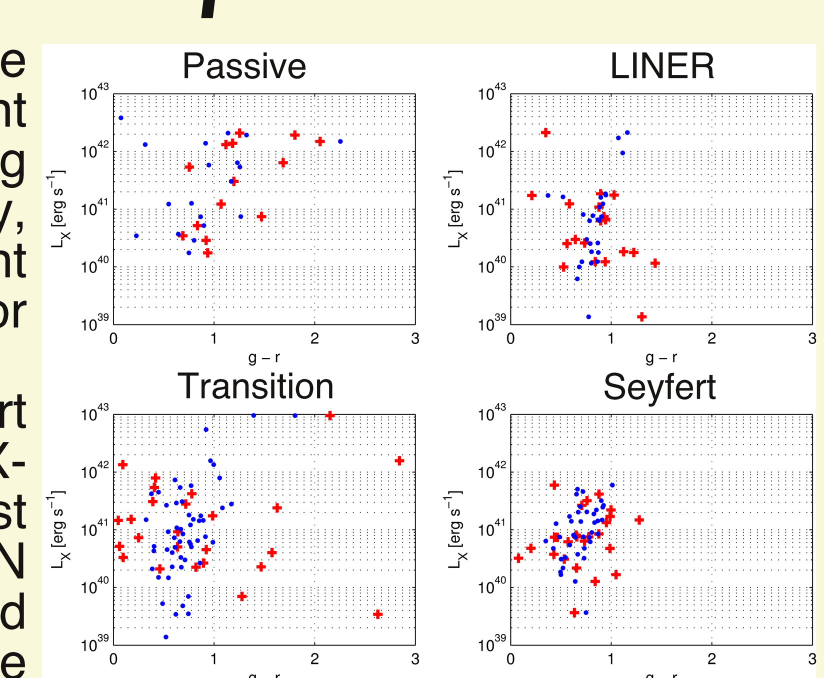


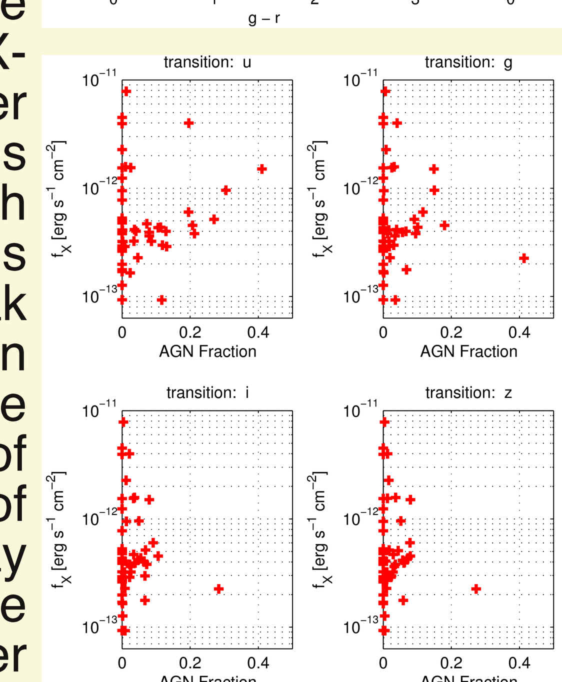
Strong correlations between 2-10 keV X-ray and optical emission line luminosity have been found for Hα, Hβ and [OIII] (Ho et al., 2001, Panessa et al., 2006) in both luminous sources and underluminous sources with high resolution X-ray data. Our data (ROSAT .2-2keV, fluxes computed with PIMMS assuming α=1, $N_H=10^{20}$) is at softer X-ray energies and lower resolution but provides a large sample size and broad range of luminosities and spectral classes. There appear to be systematic differences between the X-ray/emission line ratios between the different classes (a linear regression fit to each class is shown), with the slope increasing from quasars to Seyferts and Transitions to LINERs. Again, SDSS quasars with RASS matches are shown for reference, though note that the quasar emission lines are broad, while our galaxies have only narrow lines.

3. Photometric Properties

To model the host galaxy and AGN in the SDSS photometry, we use a two-component model, with a deVaucouleurs model including ellipticity and position angle for the galaxy, and a point source determined from the point spread function around the target galaxy for the AGN component.

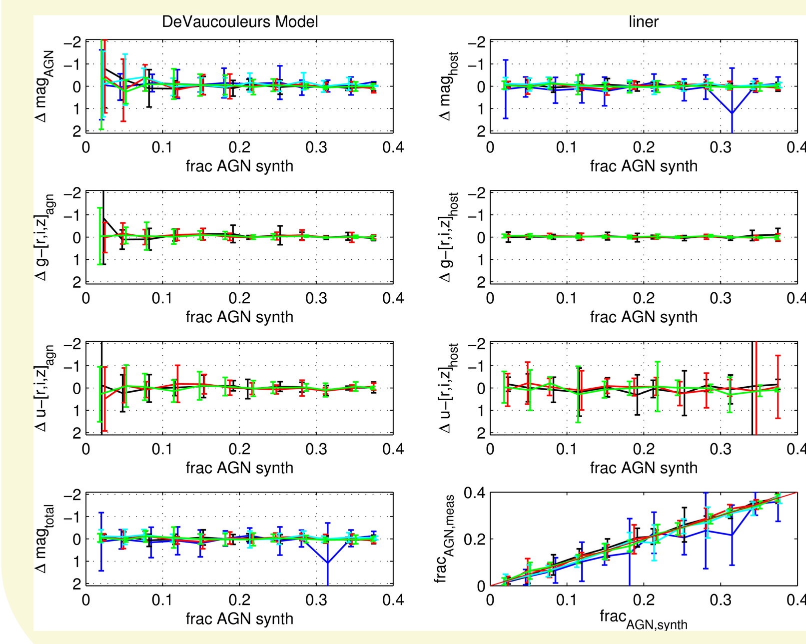
The Passive, LINER, Transition and Seyfert galaxies show different trends in color vs. X-ray luminosity (.2-2keV, as before). Host galaxy components are blue dots, AGN components are red pluses. The LINERs and Transitions show different slopes between the AGN and galaxy components, with brighter X-ray sources having bluer AGN. On the other hand, Passive galaxies have similar slopes for the AGN and galaxy components, which may be due to their high redshifts and thus their small angular sizes and weak magnitudes--the model may be extracting an "AGN" from the photometric noise. If these Passives are the bright central galaxies of high-z clusters, this could explain the trend of redder galaxy and "AGN" with brighter X-ray luminosity (redder BCGs are brighter and lie in bigger clusters which have brighter intracluster gas).





Transition: f_X vs. optical AGN fraction

Transition galaxies show a trend of higher X-ray flux with larger model AGN fraction. This trend persists across the SDSS ugriz filters, but Transitions are the only spectral class with a clear relation between X-ray flux and AGN fraction.



We perform a suite of simulations to test the reliability of our results, including synthetic galaxy + synthetic AGN and real galaxy + synthetic AGN for various galaxy types. The results of one such test are shown to the right, with real galaxies drawn from the SDSS having similar sizes and magnitudes to the LINERs discussed above. The AGN magnitude error (comparing the known synthetic AGN to the decomposed AGN) is ~.5-1 mag, and the AGN color error is ~0.25-.5 mag.

Acknowledgements & References

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