Seyfert galaxies and "Unified Scheme"

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From spectroscopic point of view Seyfert galaxies (as other Active Galactic Nuclei — AGN) basically are subdivided into two types: with and without broad permitted emission lines in their optical spectra (so called type I and type II Seyfert galaxies or AGNs). One of the most fundumental idea concerning AGN is that observed AGN type (I or II) is determined by inclination angle of AGN to the line of sight (LOS). At high inclination angles LOS crosses dusty torus which absorbs and scatters line emission. But in some recent papers the differences in close (< 100 kpc) environment of SyI and SyII (SyII have more close companions), which are incompatible with Unification Scheme, were found and the possibility of physical (intrinsic) differences between Seyfert I and II was discussed. It was shown that this difference could be due to selection effects caused by the sample criteria. We sampled SyI and SyII galaxies from the Sloan Digital Sky Survey (SDSS) on the basis of their emission line properties thus excluding selection and discuss the properties of the environment of Seyfert galaxies.

Introduction

All AGNs can be classified according to the presence (type I AGN) or the absence (type II AGN) of broad (FWHM> 1000 km/s) permitted emission lines in their optical spectra [11]. Actually such classification is wider than just dichotomy (near 2/3 of all Seyfert galaxies are intermediate types), but division typeI/typeII is clearly visible in SDSS data [6]. Traditional explanantion of type I/type II division is the existence of dusty torus in Seyfert nuclei that absorbs and scatters emission when galaxy is observed edge on. Indeed, some type II AGN displays broad lines in polarized (because of scattering) light [11]. This suggestion is called Unified Scheme (US) [8]. It has many observational evidences [4] (but see [7]) but in some recent papers its insufficiency has been found.

Different environment or selection?

The evidence of US insufficiency comes from observational fact that SyI galaxies lack of close companions as compared to SyII. According to the US isotropical properties of typeI and typeII AGN (properties that do not depend on direction of observation) must be the same. These are richness of the environment, luminosity of narrow emission lines (narrow lines are believed to originate far from nuclei — outside of dusty torus), radio luminosities. However, some papers do reveal different number of close (with projected separation less than 100 kpc) companions in SyI and SyII (see [5] and references there). Authors explain such discrepancy by evolution along SyII-SyI sequence due to decrease of star-formation rate with time after initial star-burst induced by interaction with close companion or oppositly — evolution along SyI-SyII due to decreasing AGN activity comparing to star formation. But probably such results are caused by selection. Authors of [9] claim that it is selection criteria of [5] sample that cause such selection effects. Studied in [5] SyII sample selection criteria is based on the UV-excess. But as SyII could be edge-on AGN direct view of UV-source (acretion disc) is closed and UV-flux is only available via star-formation activity that is triggered by interaction with close companions. So SyII samples constructed in this way are subject to selection of galaxies with an excess of close companions respective to other samples.

The sample

We used SDSS Data Release 7 [1] Main Galaxy Sample (MGS) to select SyI and SyII galaxies. Sample criteria based on emission lines were used to form samples. Value of 2000 km/s (in objects rest frame) for FWHM of H_α and H_β and its equivalent width (EW) of 10 Å were used to identify SyI galaxies. Flux ratios of [O III] 5007Å/H_β>3, [N II] 6583Å/H_α>0.6 [2] and EW= 2 Å for these lines were used for identifying SyII galaxies. Also we used $\frac{S}{N} = 5$ criteria for spectra and galaxies with redening $A_r < 0.2$ mag. Quasars (in common sense: type I AGN of high luminosity) were excluded from SyI sample and quasars (in terms of SDSS: any galaxy with emission lines broader than 1000 km/s) were excluded from SyII sample. It resulted in 856 SyI and 1276 SyII galaxies. For each SyI galaxy we found SyII with nearly same z-band (effective wavelength 9000 Å) luminosity and redshift. The final samples of SyI and SyII galaxies consist of 480 pairs.

Results and conclusions

Firstly we checked the basic parameter that traces inclination of galaxies from SyI and SyII samples. As all of them are mainly Sc, Sb–spirals, their inclination could be infered from axis ratio of photometric isophots measured by SDSS pipeline in r-band. We found that SyI have more rounded isophotes than it is basically expected in US. Then we used concentration parameter [10] that is a ratio of radius containing 90% of flux of the galaxy to radius containing 50% of flux as a proxy to morphology type of Seyfert galaxies. Being corrected for pointlike AGN-contribution (we estimated it from SyI galaxies with known spectral decomposition), SyI and SyII galaxies do have the same mean concentrations. Finally we compared the richness of the environment of two samples on different scales. We used *Minimal Spanning Tree algorithm* [3] to determine the frequency of falling in large scale ($\sim$ 5 Mpc) regions of low density. It turned out to be the same (less then 1σ difference) for Seyferts I and II. Then we used direct counting of close (with small projected distances and photometric redshifts) companions to compare environment on small ($\sim$ 50 kpc) scale. For projected separation of 30 kpc we found frequencies of galaxies with at least one companion 0.118±0.016 and 0.105±0.015 and for separation 50 kpc we found 0.20±0.03 and 0.21±0.03 for SyI and SyII correspondingly. Thus, in contrary to the conclusions of [5], close environment of Seyfert galaxies appears to be the same. Therefore samples of Seyfert galaxies that are free of selection reveal results predicted by Unification Scheme.

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