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Weak Emission Line Quasars

Quasars are bright cores of distant galaxies – brighter than billions of stars in their host galaxies. They are often characterized by prominent broad emission lines. However last decade quasars with weaker emission lines are founded. PhD thesis entitled "Weak Emission Line Quasars" is focused on extraordinary quasars members – Weak Emission Line Quasars (WLQ). WLQ are recently discovered class of active galactic nuclei. As investigation of its spectra showed their share properties of radio-quiet quasars but its optical and UV spectra lack strong emission lines. Most of such objects was found on high redshift (z > 2.4). In the second chapter thesis covers detailed analysis of a new WLQ member, SDSS J094533.99+100950.1, which was found to be medium redshift object (z = 1.67). The slope of the continuum is blue thus probably not reddened by extinction. Spectral analysis reveal typical iron emission (Fe II multiplets), Mg II line luminosity about 50 % weaker than typical and higher ionization lines like C IV 1-5 % of typical luminosity. Narrow absorption doublets was detected but without clear signs of broad absorption. Mass of the central black hole in the object was estimated using Mg II width with and reverberation mapping based formula to be $3\ 10^9\ M_{sun}$. This value is typical for quasars. Additionally object was found to have no radio detection and no X-ray detection.

Third chapter consist description of the accretion disc model fitting procedure. As found in the spectral energy distribution of investigated object its shape is accretion disc like. Simple Novikov-Thorne model of a geometrically thin optically thick accretion disc around rotating black hole is enough to describe broadband spectral profile. Best fit parameters for mentioned above black hole mass ($3\ 10^9\ M_{sun}$) are moderate accretion rate 0.15 (in Eddington units), moderate spin of the black hole, a = 0.6, and low inclination angle, cos i > 0.9. Possibility of additional effects causing departure from base model like limb brightening/darkening, hardening of the spectrum and intrinsic absorption was also tested. Those additions did not improved quality of the fit. This chapter showed rare situation where direct fitting of the accretion model to the quasar spectrum was possible.

Fourth chapter includes photoionization modeling of the line emitting medium with the help of Cloudy code. Aim of photoionization simulation was to find parameters of hypothetical medium which would emits lines of luminosities the same as founded in the spectrum of SDSS J094533.99+100950.1. Spectral energy distribution of the quasar was parametrized and used as an input ionizing continuum. Grid of gas clouds was computed varying in density, size and distance to the continuum source. Emission lines of the quasar are reproduced (except Al III) by medium with logarithm density [cm^{-3}] 11 located 10^{18} cm away from continuum source. Result is insensitive for the cloud size which is caused by emitting ions production in illuminated outer layers of the medium. The density agrees with the accretion disc atmosphere's density on the given radius. Radial location of the cloud agrees with expected radius estimated from reverberation mapping based formula. Alternatively to single cloud model locally optimal clouds model can be used. In this approach we integrate over whole grid of parameters to obtain summarized emission of many clouds. In this approach it was possible to find distribution parameters which resulted in similar line luminosities as in observations. Two scenarios: single cloud and locally optimal clouds differs in luminosities of emission lines which was beyond observed window thus cannot be ultimately verified at the moment.

Fifth chapter presents attempts to find more medium redshift WLQ. In this part algorithm of peak detection (emission lines) was described using modern parallel computing approach. Using two bin width 200 points and 40 points broad peaks was extracted from pseudo continuum and then detected. Supplementary Gaussian parametrization of emission lines was used. At the last stage visual selection excluding significantly absorbed emission lines or continuum was done. With combined approach final sample of 106 WLQ candidates was extracted from 61845 object with visible Mg II line. Only broad (Full Width at Half Maximum > 4000 km/s) weak lines (Equivalent

Width < 15 A) was chosen here to avoid high accretion rate objects (analogs to Narrow Line Seyfert 1 or type A objects as classified by Sulentic et al.). Histogram of masses in the selected sample is shifted toward high mass black holes (log M > 9) but histogram of accretion rates is the same as for all broad line quasars with mostly moderate rates (< 0.4 in Eddington units).

In the last discussion chapter hypotheses present in the literature was gathered. Results showed in the thesis together with those published by many authors excluded explanations based on synchrotron beamed emission which over brights emission lines. Only two most important hypotheses remained. In first WLQ are simple objects with moderately accretting black hole and undeveloped broad emission line region. In this explanation lines are intrinsically weak. Phase is not stationary, possibly stage of evolution which live for 0.2 % of quasars activity lifetime. Alternatively WLQ may be transitionally object between normal and Broad Absorption Lines quasars. In this hypothesis, like in Ton 34, we expect emission lines disappearance, heavy absorption show up and significant extinction reddening during one decade. Two hypotheses cannot be ruled out at this level. Both point out non stationary character of WLQs. Final answer can be provided by following observations of the selected sample which will show or not changes in the observed spectra thus pointing out correct scenario.