Black Holes from Stars to Galaxies – Across the Range of Masses
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Variations of geometrical and physical characteristics of innermost regions of active galactic nuclei on time-scale of years

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Abstract. Several examples of observational evidence of possible variations of geometrical and physical characteristics of the Broad Line Regions (BLR) of AGN on the time-scale of years are listed. Cases of accretion disk size variations and variable input of jets in BLR formation are presented.

Keywords. Galaxies: active – galaxies: individual (NGC 4151, NGC 5548, 3C390.3, Mrk 79, PG 1211+143, Fairall 9) – jets – nuclei – emission lines – accretion disks

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1. Accretion disk size variations

Analysis of long-term (1968–2003) variations of NGC 4151 continuum in UBV(RI) bands and K-band ($\approx 2\mu$) shows that the slow changes in the optical continuum are connected with accretion disk (AD) formation and dissipation (Lyuty *et al.* 1998; Oknyanskij *et al.* 1999; Lyuty 2005). During 1984–1989 deep minimum the former AD is assumed to totally disappear; a new AD begins to form in 1988–1989, its brightness reaching maximum in 1996 and considerably decreasing by 2003. At the same time, the fast variations ($30 - 100^d$) of the optical continuum are due to flares in AD (Lyuty 2005). Properties of the new disk are different from the previous one: it is twice as bright and shows much more intensive variations (Lyuty, Taranova & Shenavrin 1998; Lyuty 2005).

The best evidence of BLR size changes was found on the base of "AGN Watch" program data. The 13 year long intensive multi-wavelength spectral and photometric monitoring of NGC 5548 clearly shows significant variations of size (from 6 to 26 light days) of BLR emitting in Hβ spectral line on a time scale $1 - 3$ years (Peterson *et al.* 2002; Peterson *et al.* 2004).

2. Possible variable near-jet component of BLR in radio galaxy 3C390.3 and other AGN

Two maxima (flat-top peaks near $\approx 30^d$ and $\approx 100^d$) on the cross-correlation function (CCF) for Hβ broad component variation delay in respect to the optical continuum based on 3C390.3 monitoring during 1996-2001 have been found by Shapovalova *et al.* (2005). Sometimes only one of the two maxima is present, and sometimes both. The time-scale of the maxima variability is 1-2 years. Similar conclusions were drawn by Sergeev *et al.* (2002).

On the other hand, Arshakian *et al.* (2005) have found for 3C390.3 an observational evidence of connection between variations in UV and optical continua and radio-jets inner structure.

According to their scenario during the periods of the nucleus maximal brightness most of the continuum variable radiation is emitted from near-jet region at about 0.4 pc from the nucleus. The jet ionizes the surrounding gas and creates near-jet broad line emission region located rather far from the accretion disk and the "classical" BLR – another BLR appears (BLR-2). During the brightness minima the jet contribution to the ionizing continuum is decreases and the main part of broad line emission comes from the "classical" BLR (BLR-1: AD and the surrounding gas).

So, the broad-line emission is likely to be generated both near the disk (Peterson *et al.* 2002) (BLR-1, ionized by the emission from the accretion disk or/and its hot corona) and in a rotating sub-relativistic outflow surrounding the jet (BLR-2, ionized by the emission from the relativistic plasma in the jet).

Such a scenario explains the two variable maxima ($\approx 30^d$ and $\approx 100^d$) found in the CCF describing the time-lag of broad line variations relatively to continuum on the base of the results of 3C390.3 optical monitoring (Shapovalova *et al.* 2001; Sergeev *et al.* 2002). The first maximum ($\approx 30^d$) is probably connected with BLR near the accretion disk (BLR-1). The second one is assumed to indicate location of BLR-2 produced by jet activity. The time-scale of the maxima variability (1–2 years) agrees with time intervals between appearance of new knots in radio jet innermost parts.

On the base of a complete and consistent reanalysis of broad emission-line reverberation-mapping data for 35 AGN Peterson *et al.* (2004) found some similar cases of the continuum-line CCF has two peaks (at least for some time intervals and some spectral lines). One case is Hβ line in Mrk 79 during the period JD 2,449,996-2,450,220 (the highest peaks correspond to time-lags of about 6 and about 40 days). Another case is Hγ line in PG 1211+143 (about 50 and 250 days correspondingly).

Having analyzed of variations of the ratio line intensities along line profiles and the ratio variability based on UV and optical spectral line observations of Fairall 9 for the period May 1994-Jan. 1995 Nazarova & Bochkarev (2006) also arrived at the idea that it is necessary to take into account the inputs of different, spatially separated BLRs (AD and jet).

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