Abstract. A great number of spectra of the Seyfert galaxy nucleus NGC 4151 were obtained in the Crimean Astrophysical Observatory in 1988–1990 using the CCD. Significant variation in continuum intensity and broad Hα line profile were noted. Differences between individual spectra and the spectrum taken as a standard were calculated to study this variability. It was noted that different parts of the profile are varying in different ways. Smaller changes are located at far-away regions of the wings and at the low positive velocities of the profile. Lower variations in the red part of Hα profile near the center of the line are interpreted by the delay effect in an expanded shell. Since the evidences for accretion in a BLR are existing (including NGC 4151) then either the BLR is a complex system where both inflow and low velocities outflow are observed or the outflow must be referred to the inner NLR. Cross correlation analysis shows shorter delay for the higher velocities of the Hα profile and does not contradict to the outflow at low velocities (near the line center), but its confidence level is small. Lower response to the continuum changes at far away parts of the broad Hα wings evidences that the gas in the vicinity of the central engine is optically thin for the ionizing radiation.

1. Introduction

Flux variability of the broad wings of permitted lines and continuum in Seyfert galaxies and QSO gives important information about nearest to the central engine region emitting the broad lines (BLR). The works in this direction are based mostly on the method of determination the cross-correlation function (CCF) between light curve of the continuum and broad lines (Peterson and Cota, 1988; Gaskell, 1988; Maoz and Netzer, 1989; Crenshaw and Blackwell, 1990). Location of the CCF maximum (most probability lag value) gives estimation of the BLR size. Differences in the time delay at blue and red wings of a line is evidence for outflow or inflow motion of gas. That is, the variation in a profile of the broad lines with continuum changes is a clue for our understanding of the BLR kinematics. The CCF width is depended on the observational error and real kinematics in the BLR, since the response in a line is not adequate to the continuum light curve. According to Netzer and Maoz (1990), the value of the lag defined by CCF peak is depended upon the continuum variability time scale. Confidence level of delay is estimated by Monte-Carlo process (Maoz and Netzer, 1989). Different broad lines shown different lag. For instance, the lag of CIV line in NGC 4151 relative to the continuum variations at 1335 equals to 4 days (Gaskell, 1988), but in MgII line is 12 days (Gaskell, 1988). The delay of a given line seems to depend on the degree of ionization of its ion (Clavel et al., 1991). Higher ionization patterns showed less time delay, i.e., located closer to the central engine.
There exist many evidences for accretion in BLR based on CCF between red and blue wings of lines. Cross-correlation analysis for both C\textsc{iv} and M\textsc{g}\textsc{ii} lines in NGC 4151 (Gaskell, 1988) showed that the red wing variations are leading the blue ones (i.e., the inflow is observed). Recently, similar evidence emerges from the IUE observation for Seyfert galaxy NGC 5548 (Crenshaw and Blackwell, 1990; Netzer and Maoz, 1990). The C\textsc{iv} line in Fairall 9 has the same behaviour (Koratkar and Gaskell, 1989), but the M\textsc{g}\textsc{ii} line does not show differences in the lag between red and blue wings (i.e., chaotic or circular motion is observed).

Unfortunately, the time interval between observational sets described here is too large, hence linear interpolation in time is too rough. Therefore, the results of cross correlation may be distorted.

2. Observations

In 1988–1990 a great number of spectra of the Seyfert galaxy NGC 4151 were obtained in the H\textalpha region at the Crimean Astrophysical Observatory. The monitoring has been carried out on Cassegrain focus of the 2.6-m telescope using CCD as a detector. The duration of one set of continuous observations was not longer than 1–5 nights per month. Spectral resolution (FWHM of instrumental profile) was 3.5–4.0 \text{Å} with dispersion 1.52 \text{Å pix}^{-1} at H\textalpha region. The 2" slit of spectrograph was aligned with right ascension. Sixty spectra taken in H\textalpha region were used for the following data handling.

3. Data Reduction

3.1. Normalization and Subtraction of Spectra

Basically it was assumed that the profiles of the narrow lines were steady during the time of observations. In any cases the variability of narrow lines must be much smaller than that of broad lines according to spatial scale ratio between BLR and NLR. Since the profiles of narrow lines are steady, then the subtraction of any two spectra in the same intensity scale is merely a subtraction of variable components only, i.e., continuum and broad lines differences. The narrow lines have much smaller widths than the broad ones. Therefore, we can vary the scale factor of one spectrum as long as its difference from other spectrum will be smooth, i.e., without narrow details originated from the narrow lines subtraction. The spectrum with the best S/N ratio was selected and the differences between each spectrum and this one (hereafter referred to as ‘standard spectrum’) were calculated. Spline fitting of the standard spectrum was used before the subtraction. The scale factor for each spectrum was fitted by optimization method to get the most smooth difference between the spectrum and standard one. As a criterion of smoothness the value of root mean square deviation of the residuals from its filtered value was adopted, where the rectangle filter was used. The filter window size was taken approximately equal to full width of the narrow lines. Such a scale factor and difference between any individual spectrum and standard spectrum were obtained simultaneously. Unfortu-