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Double peaked structure on the broad Hα and Hβ emission line profiles in NGC 5548

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Abstract. We studied the profile variability of the broad Hα and Hβ emission lines in NGC 5548 from 1996 until 2003, using the spectral data obtained at the 6 m and 1 m telescopes of SAO (Russia) and at 2.1 m telescope of the GHO at Cananea (México) during 140 nights. The spectral resolution was 4.5 – 15 Å, and the S/N ratio was > 50 in the continuum near Hα and Hβ. Our spectra were scaled to a constant flux value for F([OIII]λ5007) and recalibrated to an equivalent aperture and the narrow emission components were removed (for detailes see Shapovalova et al. 2004.) We found that, the emission line profiles of the broad Hβ and Hα present double peaks at radial velocities ~ ±1000 km/s relative to the narrow component. The relative intensity and the radial velocity of these peaks change with time. In 2000 – 2003, we observed a third distinct peak in the red wings of Hα and Hβ, at a radial velocity of ~ +2500 km/s. This peak moved gradually across the line profile towards lower radial velocities.

Key words. galaxies: active - galaxies: individual (NGC 5548) - line: profiles

1. Results of the Hα and Hβ broad emission line profile analysis

We found that the observed mean and rms profiles as well as the annual averaged, observed and difference profiles of Hα and Hβ reveal the double peaked structure at radial velocities ~ ±1000 km/s where zero velocity is defined as that of the narrow emission components.

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The line profiles were decomposed into variable and constant components (Fig.1a,b). The variable broad component is well correlated with changes in the continuum (Fig.1, middle). It consists of the same double peaked structure with radial velocities ~ ±1000 km/s (Fig.1, top). A constant component, whose presence is independent of the continuum flux variations, shows only narrow emission lines (fig.1, bottom). The relative intensity of these peaks varied: in 1996, the red peak was brighter than the blue one. While, in 1998–2002, the blue peak was the brighter one.

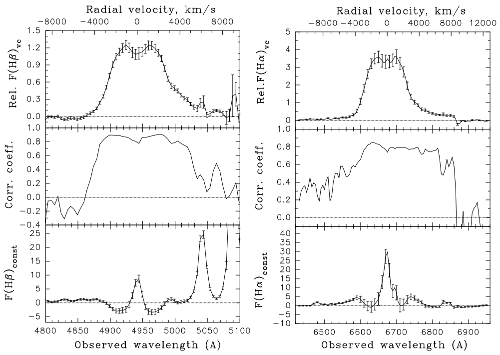

Fig. 1. The Hβ (left) and Hα (right) profile decomposition of the variable (top) and constant (bottom) components. The flux of the constant components is given in $10^{-15}\,\mathrm{erg\,cm^{-2}\,s^{-1}\,\AA^{-1}}$ units. For the variable components, the relative increment of the line flux when the continuum flux increases by an amount of $1{\times}10^{-15}\,\mathrm{erg\,cm^{-2}\,s^{-1}\,\AA^{-1}}$ is shown. The correlation coefficient between the variable component of lines and the continuum flux at different wavelengths along the line profile is shown in the middle panels.

The radial velocities of the double peaks vary within the $\sim \pm(500-1200)$ km/s interval.
Since, the double peak structure is derived after the subtraction of the narrow line components, a question arises about the reality of these features, ie. it could depend on the method of subtraction of these components. The following facts are taken as evidence to the reality of the double peaks: 1) Double-peaks are obtained on the variable component when the original Hβ and Hα profiles are decomposed, even before subtraction of the narrow components. 2) The appearance of double peaks on the difference profiles of Hβ and Hα, when the narrow emission lines and the absorption lines of the host galaxy, which may distort the observed emission line profile, are fully cancelled. Note , that the double-peaked structure in the central part of the broad lines in the radial velocity range $\sim \pm$ (500 – 1500) km/s was observed earlier. For example, double-peaks were seen in the annual averaged profiles of Hβ in 1986 – 1987 by Wanders & Peterson (1996); an on the difference Hα profiles in July 1986 - June 1985 (Stirpe et al. 1988) and in May 1987 - July 1986 (Stirpe & de Bruyn, 1991). During 2000 – 2003, when the flux of the continuum and the lines greatly decreased, a new distinct peak at a radial velocity of $\sim +2500$ km/s appeared on the profiles of Hα and Hβ. This peak had comparable brightness to the blue peak at a radial velocity of $< \;\sim -1000$ km/s. The radial velocity of this peak decreased: in 2000–2001 it corresponds to $\sim +(2500-2600)$ km/s, and in 2002–2003 to $\sim +2000$ km/s.

2. Conclusion

The appearance of double peaked structures in the profiles of broad emission lines is predicted by different types of models. We support the scenario of the formation of the broad Balmer lines in NGC 5548 in a turbulent accretion disc with large non stationary "optically thick" inhomogeneities, capable of reprocessing the central source continuum (for a more detailed discussion see Shapovalova et al., 2004).

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