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Jet-linked X-ray emission in radio-loud broad absorption line (BAL) quasars

M. Kunert-Bajraszewska[1], K. Katarzyński[1], A. Janiuk[2], and M. Cegłowski[1]

[1]Toruń Centre for Astronomy, N. Copernicus University, Gagarina 11, 87-100 Toruń, Poland
email: magda@astro.uni.torun.pl

[2]Center for Theoretical Physics, PAS, Al.Lotnikow 32/46, 02-668 Warsaw, Poland

Abstract. We have applied theoretical models to explain spectral energy distribution (SED) of three radio-loud broad absorption line (BAL) quasars: an extended hybrid object PG 1004+130 and two compact sources 1045+352 and 3C270.1. We calculate the emission from the very inner part of the sources which accounts for more than 90% of the observed X-ray radiation. In our analysis we consider a scenario in which the observed X-ray emission comes from the inverse-Compton (IC) scattering inside a jet and from the accretion disk corona. The compact objects 1045+352 and 3C270.1 are high-redshift quasars ($z = 1.604$ and 1.532 respectively), with strong radio cores. We argue that in the case of these two sources a non-thermal, inverse-Compton emission from the innermost parts of the jet can explain a large fraction of the observed X-ray emission. The large scale object PG 1004+130 with a peculiar radio morphology is a low-redshift (z=0.24), lobe-dominated BAL quasar with a weak radio core. In this case simulated inverse-Compton X-ray emission of the jet is relatively low. However, the corona emission appears strong enough to explain the observed X-ray spectrum of this object.

Keywords. Physical data and processes: accretion, quasars: individual (1045+352, 3C270.1, PG 1004+130)

1. Introduction

According to the established paradigm, optical to UV emission of quasars results from accretion onto a super-massive black hole. The photons from optical to UV or even to soft X-ray range are produced by the accretion disk. In addition, the corona that surrounds the disk may produce hard X-rays. The radio-loud quasars (those with radio loudness $R^* \geqslant 1$, Stocke *et al.* 1992) constitute a sub-class of quasars having strong radio emission linked to the presence of jets. Zamorani *et al.* (1981) demonstrated that radio-loud quasars are more X-ray luminous than radio-quiet quasars with comparable optical/UV luminosities. The excess of the X-ray emission increases with the radio loudness (Worrall *et al.* 1987). This may suggest a common physical background for both phenomena. However, it is still unclear which components and processes can contribute to the total X-ray emission. The non-thermal emission of the small-scale jet or the emission related to the accretion disk and hot corona, or both.

We focus here on BAL quasars, where the X-ray continuum probably contains both: disk-corona and small-scale jet emission (Miller *et al.* 2009, Kunert-Bajraszewska *et al.* 2009).

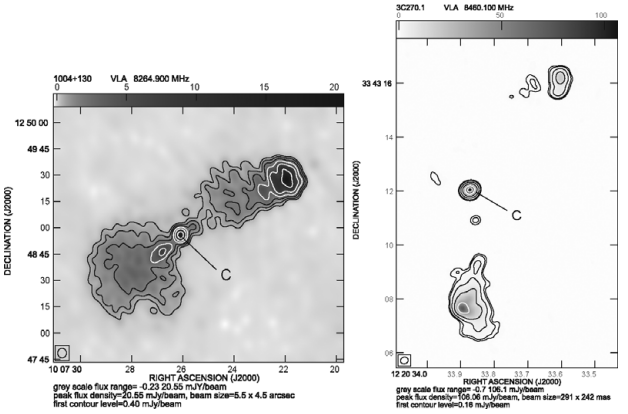

Figure 1. Radio 8 GHz VLA images of PG 1004+130 and 3C270.1. First contour level corresponds to 3σ. Indications: C - radio core.

2. Discussion and Results

Two of the studied quasars, PG 1004+130 and 3C270.1 are classified as large scale (linear size >20 kpc), radio-loud AGNs. Their radio structures are well resolved with VLA (Fig. 1), showing central component - radio core and jets/lobes on both sides. As already discussed in the literature, the X-ray emission that comes from the outer parts of the radio jet and the hotspots, in the case of PG 1004+130 and 3C270.1, could have either synchrotron or IC origin, but it accounts for $\sim$ 2% of the whole observed X-ray emission. Most of the observed X-rays come from the very centre of the sources, where the radio cores (component *C*, Fig. 1) are probably connected with the small-scale jets. The detailed study of the third quasar, 1045+352, has been already presented in Kunert-Bajraszewska *et al.* (2009).

Broad-band spectra of PG 1004+130 and 3C270.1 are characterized by the strong radio emission, a peak in the IR range, and relatively strong UV-X-ray continuum. We used a simple synchrotron self-Compton model of the jet emission and also corona X-ray emission model to analyse central regions of both quasars. We argue that in the case of two core-dominated sources, 1045+352 and 3C270.1, a non-thermal, inverse-Compton emission from the innermost parts of the radio jet can account for a large fraction of the observed X-ray emission. In the case of lobe dominated, weak radio core object PG 1004+130, the X-ray emission of the accretion disk and corona are needed to explain the observed X-ray emission. The central region of PG 1004+130 appears to be too weak to produce significant part of the observed X-ray emission.

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