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ORIGINAL ARTICLE

Properties of radio-detected broad absorption line quasars from the Sloan Digital Sky Survey

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Abstract We investigate the optical colors and radio morphologies of 214 broad absorption line (BAL) quasars with FIRST detections in the redshift range $1.68 \leq z \leq 4.93$ drawn from the Sloan Digital Sky Survey (SDSS) Data Release 5 (DR5) quasar catalog. The radio-detected SDSS BAL quasars are found to have $\Delta(g-i)$ colors significantly redder than their non-BAL counterparts, with a mean color difference of 0.52 mag, in good agreement with the O–E (roughly B–R) color difference between radio-selected BAL and non-BAL quasars in the FIRST Bright Quasar Survey (FBQS). The vast majority (∼90 %) of the radio-detected BAL quasars are found to be core-only sources, most of which show compact radio morphologies, consistent with the morphological results for the FBQS sample. Moreover, within the FIRST-detected SDSS sample, BAL quasars with GB6 detections are found to span a wide range in radio spectral indices, indistinguishable from that of non-BAL quasars, indicating no special line of sight for the presence of BALs. The properties of the present SDSS sample are more consistent with the evolutionary model, in which BALs are at an early evolutionary stage of quasars.

Keywords Quasars: absorption lines · Quasars: general · Radio continuum: general

1 Introduction

Approximately one in every six optically selected quasars exhibits broad absorption lines (BALs) in its spectrum (e.g. Reichard et al. 2003b; Knigge et al. 2008), with the absorption troughs arising from outflowing gas with velocities up to a few tenths of c. According to transitions, the BAL quasars can be divided into three classes, namely high-ionization, low-ionization, and iron low-ionization (e.g. Hall et al. 2002). The high-ionization BAL (HiBAL) quasars are primarily identified through broad absorption from C IV and/or Si IV which is most commonly detected, while the low-ionization BAL (LoBAL) quasars that comprise some 10–20 % of the total BAL population (e.g. Weymann et al. 1991; Reichard et al. 2003b) can be identified through Mg II and/or Al III absorption. Note that LoBALs also show strong absorption from high-ionization transitions. The rare class of iron LoBAL (FeLoBAL) can have additional strong absorption from excited-state Fe II and/or Fe III (e.g. Becker et al. 1997; Hall et al. 2002).

Theoretical models that attempt to explain the presence of BALs in quasars can be characterized as either "unification by orientation" or "unification by time" (e.g. Hewett and Foltz 2003). The orientation model assumes that BAL and non-BAL quasars are in fact intrinsically similar, and the frequency of observed BALs and the differences between BAL and non-BAL quasars are ascribable to orientation effects. In this model, BAL clouds are accelerated to high velocities by the wind which originates in the surface of the quasar accretion disk (e.g. Elvis 2000; Proga et al. 2000), BALs are therefore only observed when quasars are seen with their disks nearly edge-on. Evidence that support this picture is that BAL and non-BAL quasars are found to have indistinguishable emission line properties and appear to be drawn from the same parent population (e.g. Weymann et al. 1991).

The evolutionary model, on the other hand, assumes that BALs are an early phase in the evolution of quasars (e.g. Becker et al. 2000; Gregg et al. 2006). In this picture, BAL

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