Instituto de Física
Universidade de São Paulo

HOW SATURATED ARE ABSORPTION LINES IN THE BROAD ABSORPTION LINE QUASAR PG 1411+442?

T.G. WANG, [1,2] J.X. WANG,[2] W. BRINKMANN,[3] M . MATSUOKA [1]

[1]*The Instituto of Physical and Chemical research (RIKEN), 2-1, Hirosawa, Wako, Saitana, 351-0198, Japan*

[2]*Center for Astrophysics, University of Science and Technology of China, Anhui, 230026, China*

[3]*Max -Plank-Istitut fur extraterrestrische Physik, Giessenbachstrasse, D-85740 Garching, FRG*

Publicação IF - 1422/2000

HOW SATURATED ARE ABSORPTION LINES IN THE BROAD ABSORPTION LINE QUASAR PG 1411+442 ?

T.G. WANG,[1,2] J.X. WANG,[2], W. BRINKMANN,[3] M. MATSUOKA [1]

ABSTRACT

Recently, convincing evidence was found for extremely large X-ray absorption by column densities $> 10^{23}$ cm^{-2} in broad absorption line quasars. One consequence of this is that any soft X-ray emission from these QSOs would be the scattered light or leaked light from partially covering absorbing material. A detection of the unabsorbed soft X-ray and absorbed hard X-ray component will allow to determine the total column density as well as the effective covering factor of the absorbing material, which can be hardly obtained from the UV absorption lines. Brinkmann et al. (1999) showed that both the unabsorbed and absorbed components are detected in the nearby very bright broad absorption line quasar PG 1411+442. In this letter, we make a further analysis of the broad band X-ray spectrum and the UV spectrum from HST, and demonstrate that broad absorption lines are completely saturated at the bottom of absorption troughs.

Subject headings: quasars: absorption lines –X-rays: galaxies – quasars:general

1. INTRODUCTION

About 10% of quasars (QSO) found in the optical flux-limited samples exhibit broad absorption lines (BAL), resonance line absorption troughs extending $\sim 0.1c$ to the blue of the emission line centers (Weymann et al. 1991). However, Goodrich (1997) and Krolik & Voit (1998) argued that the true fraction of BAL QSO can be as high as > 30% considering attenuation of the light or a non-spherical distribution of continuum emission. Based on the similarity of emission line properties, it is generally thought that BAL regions exist in all quasars, but occupy only a fraction of the solid angle (e.g., Weymann et al. 1991). Thus a BAL region is an important part of every QSO's structure.

The absorption line properties of BAL QSO have been intensively studied, however, results on the nature of the absorbing material from the UV absorption lines alone are rather controversial.

[1]The Institute of Physical and Chemical Research (*RIKEN*), 2-1, Hirosawa, Wako, Saitama, 351-0198, Japan

[2]Center for Astrophysics, University of Science and Technology of China, Anhui, 230026, China

[3]Max-Planck-Institut für extraterrestrische Physik, Giessenbachstrasse,D-85740 Garching, FRG

All earlier results indicated low column densities of about an equivalent N_H density around $10^{20\sim21}$ cm^{-2} on the assumption that the absorption is not too optically thick, but metal abundances far higher than the solar values are required (Korista et al. 1996; Turnshek et al. 1996; Hamann 1996). However, recent results show that the structure of the absorbing material is rather complicated and seriously saturated in some velocity range in PG 0946+301 (Arav et al. 1998). The total column density could be much larger. One major difficulty, however, is the lack of an independent measurement of the covering factor.

In the soft X-ray band, BAL QSO are notorious for their weakness (Green et al. 1995, Green & Mathur 1996). It was argued that the BAL QSO are not intrinsically X-ray weak, but heavily absorbed in the soft band. Great similarity of the emission line spectra in BAL and non-BAL QSO indicates that the BLR clouds have seen a similar ionizing (UV to X-ray) continuum in both type of QSO (Weymann et al. 1991).

Heavy absorption has been found in the one of two ROSAT detected BAL QSO. Green & Mathur (1996) showed that the spectrum of 1246-057 is absorbed by an intrinsic column of $\sim1.2\times10^{23}$ cm^{-2}. A similar column density was found in the ASCA spectrum of PHL 5200 (Mathur et al. 1996). More BAL QSO still remain to be discovered in the X-ray band. From the ROSAT non-detection, Green & Mathur (1996) derived a lower limit for the absorption column densities of $\sim 10^{23}$ cm^{-2} for these objects if the intrinsic X-ray emission is similar to other quasars. A similar conclusion has been reached by Gallagher et al. (1999). Brinkmann et al. (1999) analyzed the ASCA spectra of three BAL QSO; only the brightest, low redshift (z=0.0896, Marziani et al. 1996) BAL QSO PG 1411+442 has been detected with a column density of $\sim$2 10^{23} cm^{-2}.

At these column densities, photons below 1 keV are completely absorbed. Any soft X-ray emission from a BAL QSO must be either scattered light or the light leaking from a partially covering absorber. Therefore, the measurement of the unabsorbed component in soft X-rays and the absorbed ones in the hard X-ray band will enable us to determine the fraction of light scattered or leaked, thus providing an independent measurement of the effective covering factor of absorbing material. Both, scattered light and absorbed hard X-rays were detected in the nearby bright BAL QSO PG 1411+442 (Brinkmann et al. 1999).

In this *Letter*, we make a further analysis of the broad band X-ray spectrum and the UV absorption line spectrum from HST. We will show that the UV absorption lines are completely saturated in the deepest part of the absorption trough.

2. X-RAY ABSORPTION AND SCATTERING

Brinkmann et al. (1999) found that the combined ROSAT and ASCA spectrum can be well fitted by a heavily absorbed power law at high energies plus an unabsorbed power law at low energy with a much steeper spectrum. They noticed that the steepness of the power law in the