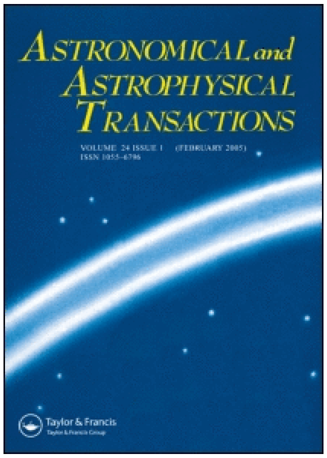

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THE WARM ABSORBER OF THE QUASAR MR2251-178

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MR 2251-178 was the first quasar initially discovered in X-rays, and the first one found to host a warm absorber. The quasar has a high ratio of X-ray to optical luminosity, is surrounded by a giant HII gas envelope, and is located in the outskirts of a cluster of galaxies. Here, we present results from an analysis of the X-ray spectral and variability properties of this source based on deep ROSAT observations. In particular, the warm absorber is modeled in detail.

KEY WORDS Active galaxies: MR2251-178, warm absorbers, photoionization modeling

1 INTRODUCTION

Warm absorbers are an important diagnostic of the physical conditions within the central regions of active galaxies. They have been observed in ~50% of the well-studied Seyfert galaxies (see Komossa, 1999 for a review). Their presence was recently confirmed with *Chandra* observations of NGC 5548 which revealed a rich absorption line spectrum (Kaastra *et al.*, 2000). The study of the ionized material provides a wealth of information about the nature of the warm absorber itself, its relation to other components of the active nucleus, and the intrinsic AGN X-ray spectral shape. Modeling of the few *quasars* that show warm absorbers, like MR2251-178, is also important for investigating the relation between warm absorbers in Seyferts and quasars and the cause of their different abundances.

MR2251-178, at $z = 0.064$, was detected as a bright X-ray source in the course of the *Ariel V* all-sky survey (Cooke *et al.*, 1978) and identified with the quasar by Ricker *et al.* (1978) from observations with the *SAS-3* X-ray Observatory. It was the first quasar initially identified from *X-ray* observations. Halpern (1984) suggested the presence of a warm absorber in MR2251-178, based on *Einstein* observations.

2 RESULTS OF THE X-RAY ANALYSIS

Based on an analysis of a deep *ROSAT* PSPC X-ray observation of MR2251-178, we obtained the following results:

The mean source count rate was 3.1 cts s^{-1}, a factor of 3 higher than during the *ROSAT* all-sky survey observation performed 3 yrs earlier. Short-timescale variability of order 20% on the timescale of 1000 sec is present.

A single power-law spectral fit to the data gives $\Gamma_x = -2.3$ and $\chi^2_{red} = 5.4$, completely unacceptable. The column density of cold absorbing material was fixed to the Galactic value towards MR2251-178, $N_{H,Gal} = 2.77 \times 10^{20}$ cm^{-2}. If N_H is treated as free parameter, it does not exceed the Galactic value. Among various non-power-law spectral models compared to the data (like a power-law plus soft excess, or Raymond–Smith emission), we failed to obtain any acceptable fits.

The presence of a warm absorber markedly improves the fit. Performing a two-edges fit with edge energies fixed at the theoretical values of OVII and OVIII we obtain $\tau_{OVII} = 0.26 \pm 0.12$, $\tau_{OVIII} = 0.20 \pm 0.12$, and $\Gamma_x = -2.20 \pm 0.02$. Next, a warm absorber model based on photoionization calculations (see Komossa and Fink, 1997 for details) with the code *Cloudy* (Ferland, 1993) was applied. We find an ionization parameter $\log U = 0.5^{+0.3}_{-0.2}$ and a column density of the warm absorber $\log N_w = 22.6^{+0.2}_{-0.1}$. We then split the total data set into three subsets according to the flux-state of the source, and fit these data separately. The best-fit parameters remain the same within the error bars; no changes in the warm absorber are detected. We have checked that none of the observed optical-UV emission lines of MR2251-178 are over-predicted by our best-fit warm absorber model. For instance, we derive a warm-absorber intrinsic intensity ratio in the emission lines [FeXIV]λ5303/Hβ of 0.02.

Finally, we have searched for excess cold absorption in the X-ray spectrum of MR2251-178 which is expected to be present if the giant HII emission line nebula that surrounds the quasar possesses an HI extension (e.g., Bergeron *et al.*, 1983; Shopbell *et al.*, 1999). However, interestingly, there is no evidence for cold absorbing material along the line of sight in excess of the Galactic value. This finding constrains models for the origin of the giant emission-line envelope.

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