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The Foreground to the Hot Universe

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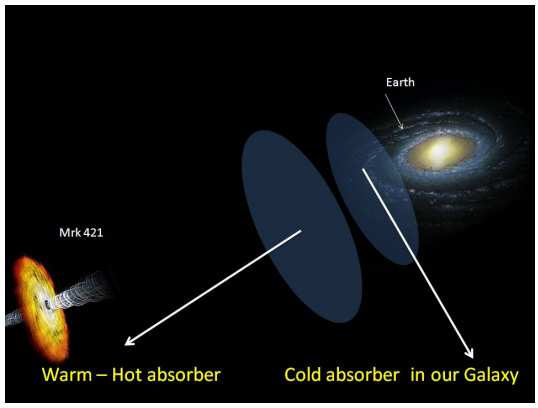
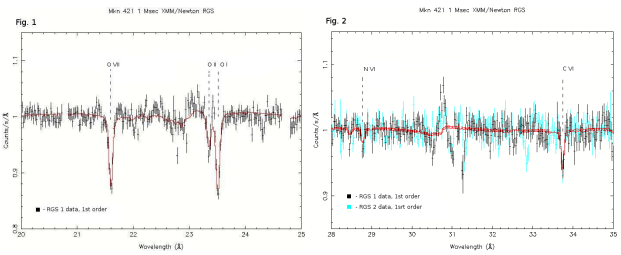
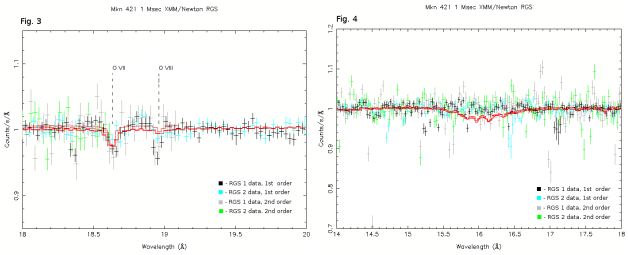
Introduction

We present the results of the analysis of the very high signal-to-noise XMM-Newton Reflection Grating Spectrometer (RGS) spectrum of the blazar Mkn 421 with the exposure time of ~ 1 Ms. Because blazars are very bright continuum sources, they are ideal backlights to detect intervening absorbers. We report the results of the analysis of the physical properties of both the cold interstellar medium (ISM) and of the ionized gas with the temperature of 1.3×10^6 K which could be part of the Galactic Halo or the intergalactic medium of our Local Group.







Our Galaxy or Local Group?

We confirm the presence of the following absorption lines from the ionized absorber: OVII 1s-3p Heβ transition at 18.64 Å (Fig.3) and OVII 1s-2p Heα transition at 21.60 Å (Fig.1), O VIII 1s-2p Lyα at 18.95 Å (Fig.3), C VI 1s-2p Lyα at 33.75 Å and N VI 1s-2p transition at 28.79 Å (Fig.2). The best fit temperature of the absorber is 1.3×10^6 K and its hydrogen column density is 1.0×10^{19} cm^{-2}. At these temperatures Fe absorption lines are expected to be seen in the 15 – 17 Å range of the spectrum. However, they are expected to be very weak. For illustration purposes, in Figure 4 we show a model with an exaggerated Fe abundance of 8 times solar. Even with the high signal-to-noise ratio of our spectrum we can only determine a very rough Fe/O abundance ratio which is 0.5±0.4. It indicates a strong contribution of Type II supernovae in the chemical enrichment of the warm absorber.

We estimate the thickness of the absorbing gas layer to ≈50 kpc. We can not exclude either the Galactic Halo origin of the absorber nor that it is the intergalactic medium of our Local Group.

Interstellar Medium

The spectrum shows a strong O I absorption line at 23.51 Å and a nearby O II absorption feature at 23.35 Å (Fig.1). While the O abundance determined from the neutral oxygen edge is consistent with the solar value, the O abundance determined from the O I line is ∼0.25 solar, suggesting that at least 75% of oxygen is in the form of dust grains. The OII absorption line could be associated with a warm 30,000 K interstellar absorber or with molecular oxygen. For solar abundance ratios in the absorber we also expect the presence of a strong Fe I absorption line at 17.44 Å. However, this line is missing. The lack of the Fe I absorption might mean that iron is underabundant in the ISM or that it is distributed in grains with various compositions.

The formal upper limit on Fe I in the absorbing gas is 0.08 solar and the upper limit on the Fe/O ratio in the gas is 0.32 solar.