ABSORPTION MEASURE DISTRIBUTION IN AGNS: MODELS VERSUS OBSERVATIONS

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The most common observed feature of the outflows in several active galactic nuclei (AGNs) is their broad ionization distribution spanning up to $\sim$ 5 orders of magnitude in ionization levels. This feature is quantified in terms of absorption measure distribution (AMD), defined as the distribution of column density with the ionization parameter. Recently, the photoionization models with constant pressure assumption i.e., (P_{rad}+P_{gas} = constant) are shown to well reproduce the observed shape of AMD. However, there exist inconsistencies in the normalisation and discontinuities present in the AMD shape between the observation and model. In this work, we compute the models using the photoionization code TITAN and show that AMD normalisation and discontinuity depends on the shape of the ionising spectral energy distribution (SED).

AMD from observations

AMD in AGN outflow is defined as the distribution of matter column density with the ionization parameter along the various layers of the line of sight as given by

$$AMD = \left|\frac{dN_H}{d\,(log\ \xi)}\right| \quad \text{Holczer et al. (2007)}$$

where, N_H is the total column density along the line of sight and ξ is the ionization parameter. The detections of X-ray blue shifted absorption lines with their enrgy centroids corresponding to the ions of broad ionization states (different charge states of Fe in particular) show that the warm absorber in the outflow of Seyferts is broadly stratified in ionization levels. The ionic column density for an individual ion is obtained by fitting the corresponding absorption line in the observed high resolution X-ray AGN spectra and later it is used to derive the shape of the AMD. For the detail procedure to derive AMD from observations, we refer the reader to the paper by Holczer et al. (2007). Behar (2009) studied outflows in 5 Seyfert galaxies and showed the AMDs derived from observations span up to 5 orders of magnitude in ξ with prominent discontinuity between log$\xi \sim$ 0.5 and 1.5. However in case of Seyfert 1 galaxy Mrk 509, Detmers et al. (2011) showed that the AMD contains two strong discontinuities around the ionization degree log$\xi \sim$ 2-3 and 3-4. The interpretation of these AMD discontinuities is the presence of thermally unstable zones in the outflow. So the main motivation for our work is to answer the question: what causes the variation in the number of AMD dips and normalization in different sources?

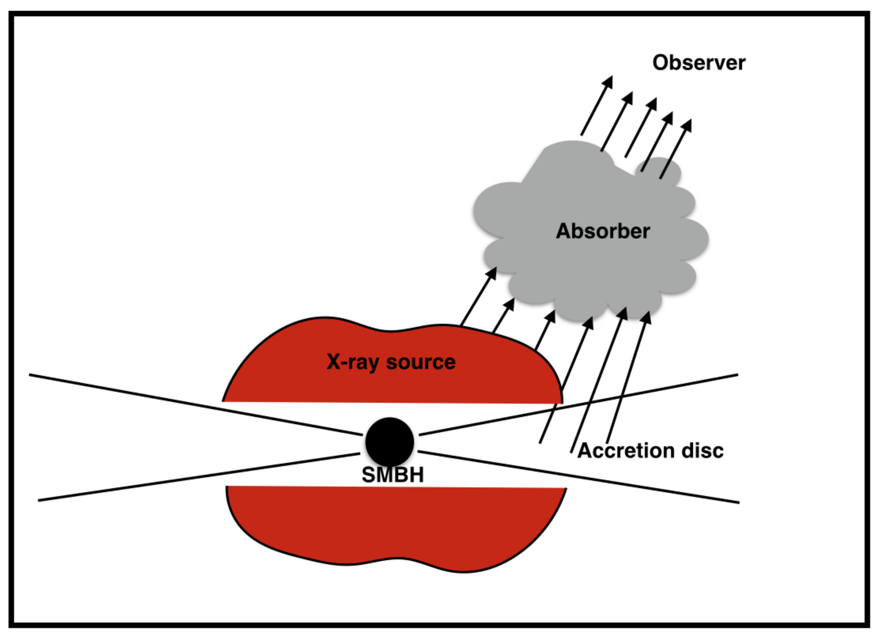

Figure 1: A schematic diagram showing the X-ray absorber

AMD modelling using the photoionization code TITAN

The recent photoionization modelling of an outflowing X-ray absorber in AGNs favours the constant total pressure models over the constant density models (Rozanska et al. 2006; Stern et al. 2014; Adhikari et al. 2015). One of the most important assumptions in the constant pressure models is self consistent stratification in the density and ionization accross the different layers of a single gas clouds. Stern et al. (2014) showed that the observed AMD normalisation can be well produced by using radiation pressure confinement (RPC) model, i.e. constant pressure model in CLOUDY (Ferland et al. 2013) numerical code. RPC model in cloudy is not successful in explaining the gap present in the observed AMD. Nevertheless, Adhikari et al. (2015) have demonstrated that the constant pressure model computation using the numerical code TITAN (Dumont et al. 2000) well reproduces the observed AMD gap in Mrk509. However, the AMD normalisation in their model is overpredicted by a factor of $\sim$ 30 from the observed one (shown in Fig. 2). In this work, using TITAN numerical code, we investigate how does the AMD normalisation change with a shape of a ionising continuum radiation.

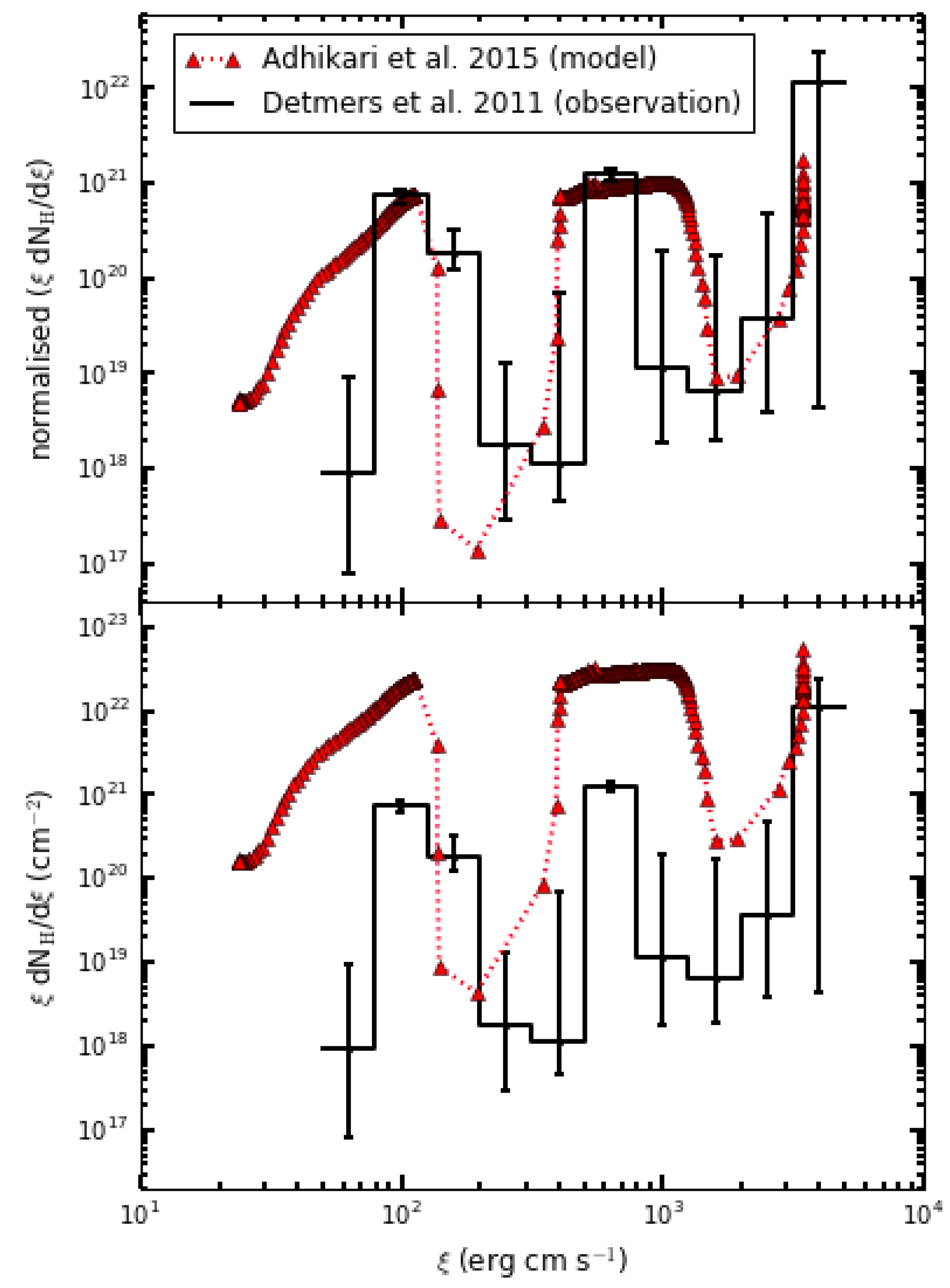

Figure 2: Comparison of the AMD model obtained with TITAN to that from observations for Mrk 509. Absolute AMD (bottom panel) and normalised AMD (upper panel) are presented.

Dependence of AMD on the incident SED

We considered the SED shapes computed for two cases of mass accretion rates and the flux ratios between the disk emission and X-ray power laws as shown in Fig. 3. The resulting SEDs can be mainly classified into two groups: i) SED group A with strong disk component and weak powerlaw tail and ii) SED group B with weak disk component and strong powerlaw tail. The AMD models computed for each cases of SED using the TITAN photoionization code are shown in the two panels of the Fig. 4. We found that the AMD models obtained for the SED group B has higher normalisation (right panel) by the factor of $\sim$ 25 than the models with the SED group A (left panel).

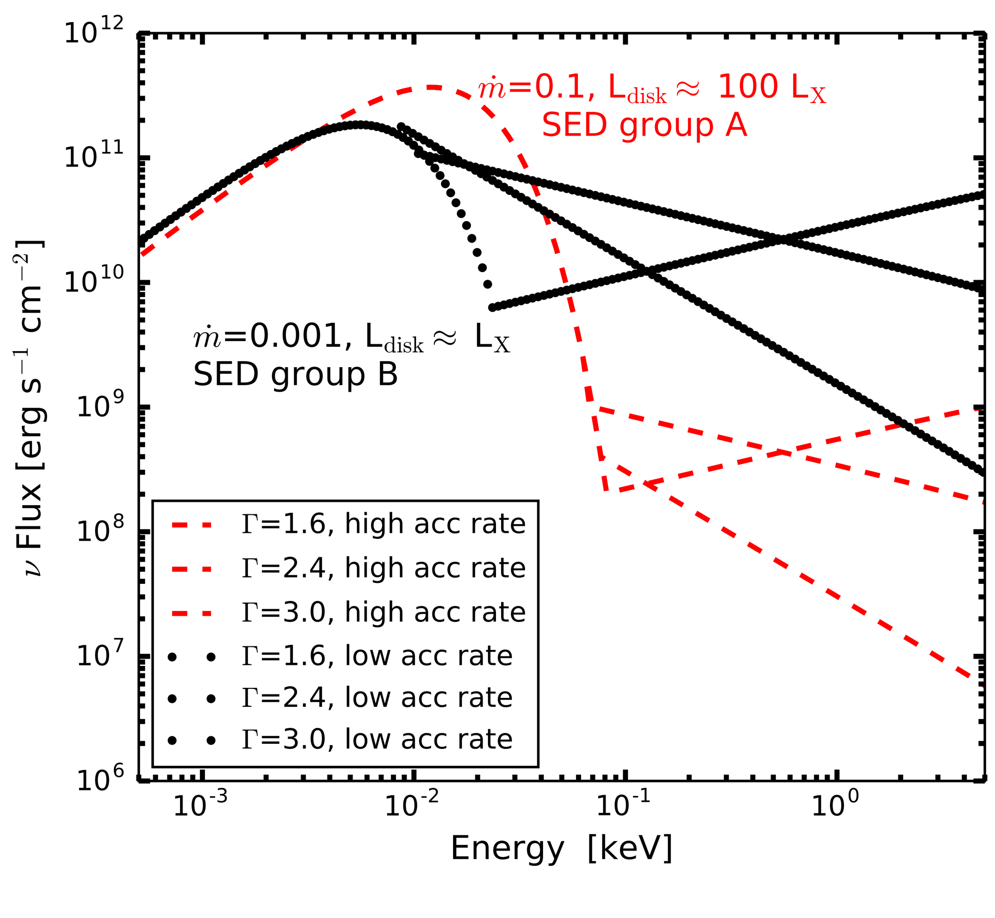

Figure 3: SED shapes used in our models

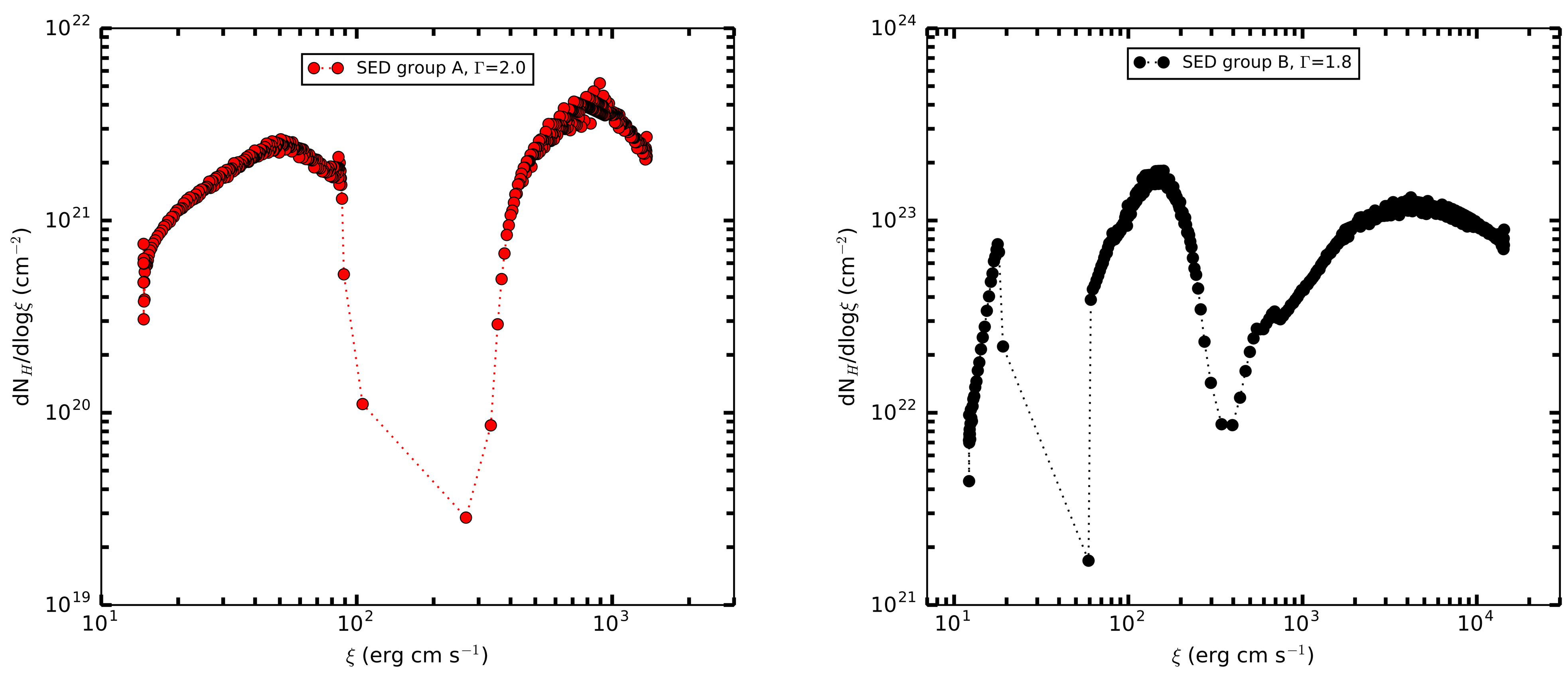

Figure 4: AMD models in TITAN for two cases of SEDs shown in Fig. 3 and the gas density 10^8 cm^{-3} at the cloud surface.

Our results show that the shape of the incident radiation changes the normalisation of AMD models. Strong disk component with weak hard X-ray powerlaw produces lower AMD normalization. The physical reason for this behaviour is likely to be connected with a switch between the gas heating-cooling mechanism, i.e., from Comption heating to the free-free heating as the SED changes from strong powerlaw X-ray component to the strong optical/UV component. Adhikari et al. (2015) found that in case of Mrk 509 SED, the AMD displays only a single discontinuity when the gas density becomes higher. These results show that the dependence of AMD on the SED and the gas density is degenerated and we need to compute the models with large parameter space to make a firm conclusion. The next generation X-ray mission *ATHENA* with its high resolution instrument *X-IFU*, will be able to resolve more absorption lines with unprecedented details allowing the better understanding of AMD nature from observations.

References

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